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EHICLE DETECTION--PHASE III
ASSIVE BUS DETECTOR /
INTERSECTION PRIORITY SYSTEM DEVELOPMENT

Vol. III. Vehicle Signature Acquisition

Dept. of Transportation
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December 1975
Final Report

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16. Abstract

Analysis and design of a successful passive bus detector cannot even begin until the characteristic features of the bus and other vehicles are known. These characteristic features are contained in the time history signals (signatures) detected by transducers located in the pavement. Three transducers were candidates for the passive bus detector: the inductive loop detector (ILD), the magnetic-gradient vehicle detector (MGVD), and the magnetometer. Early analysis eliminated the magnetometer from the candidate list. A total of 450 signatures were acquired from the ILD and MGVD from various vehicle types and test conditions. These signatures depicted all necessary feature data for the vehicles and test conditions, and allowed for subsequent analysis, design, and demonstration of a successful passive bus detector.

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SECTION I
INTRODUCTION

The concept of passive bus detection is based on deriving a unique signature of a bus from a transducer buried in the roadway. This unique bus signature would possess distinctive features which can be detected or otherwise computed using a combination of electronic circuitry and software for a microprocessor computer. To prove this concept, a large vehicle signature library was acquired, examined, and subjected to computer operations aimed at developing a bus classifier. This report discusses the acquisition of the vehicle signature library which was subsequently used to successfully develop a bus classifier and a passive bus detector.

The signature acquisition described by this report deals with vehicle signatures acquired from the inductive loop detector and the magnetic-gradient vehicle detector. Federal Highway Administration Report No. FHWA-RD-7522 should be used for similar signature acquisition using the magnetometer sensor.

SECTION II
SUMMARY

Vehicle signatures were acquired from the inductive loop detector (ILD) and magnetic-gradient vehicle detector (MGVD). The MGVD is a new transducer invented by the FHWA; its prototype development is described in Federal Highway Administration Report No. FHWA-RD-7519. Two sets of transducers were used for this activity; one set (ILD and MGVD) was installed in nonreinforced asphalt, and one set was installed in reinforced concrete. Both the ILD and MGVD were measured for their respective phase and amplitude responses to vehicles. With the MGVD transducer, separate signatures were acquired with the transducer optimized in either the "amplitude" or "phase" mode.

Signature acquisition used laboratory instrumentation-grade equipment to extract the desired signals from the vehicles. These signals (signatures) were then recorded on magnetic tape and strip-chart recordings.

Signatures were always acquired with the vehicle operating at some finite velocity over the transducers, usually 10 mph. Signatures were acquired with a lateral displacement of the vehicle centerline to the transducer centerline at zero feet, ±3 feet, and ±6 feet. Environmental conditions included clear weather, snow, ice, and slush-salt. Eleven vehicle types were used, including two bus types. Because of the project objective to develop a passive bus detector, all vehicles were not subjected to all possible physical or environmental conditions. In many cases, only representative samples were acquired to determine deleterious effects of the condition, if any.

SECTION III
OBJECTIVE

The objective of this effort was to acquire vehicle signatures of sufficient magnitude and variety to provide a high confidence in the successful development of a passive bus detector.

SECTION IV
TECHNICAL DISCUSSION

TECHNICAL OBJECTIVES

The magnetic and electromagnetic signatures of a representative sample of transit buses and typical urban vehicles were to be acquired using:

- Three-axis magnetometer
- Six-foot by six-foot, three-turn inductive loop
- MGVD optimized for amplitude operation
- MGVD optimized for phase operation

The signatures were to be acquired with the transducers installed in asphalt, nonreinforced concrete, and reinforced concrete. Signatures were to include a representative sample of all types of vehicles anticipated in the urban traffic scenario.

If preliminary signature measurements determined that asphalt and nonreinforced concrete provided similar data, further signature measurements were not to be conducted using nonreinforced concrete. Similarly, if preliminary signature measurements demonstrated that a given class of vehicles, test condition, or environmental condition would result in similar data, signatures would only be measured for the representative vehicle, test, or environmental condition. All tests were to document or otherwise note the particulars involving vehicle characteristics, vehicle position over the transducers, and test environmental conditions.

All test data were to be acquired using instrumentation-grade data acquisition equipment having sufficient capability to extract an accurate time history of the event. The test data were to be recorded on strip-chart and instrumentation tape recorders.

METHOD OF APPROACH

To accomplish the technical objectives, the following initial steps were undertaken:

1) Measurements were taken using the ILD and MGVD transducers in asphalt and nonreinforced concrete and any significant differences existing between the two roadway mediums determined.

2) Based on the results of the above item, a Honeywell Vehicle Test Facility was developed to provide a controlled test site for vehicle signature acquisition and subsequent system performance evaluation. The facility was designed for use in long-term contract and noncontract vehicle detection and classification activities.

3) Vehicle signatures were acquired on magnetic tape and strip-chart recordings at the Honeywell Vehicle Test Facility in accordance with the technical objectives denoted in this report and the project objective.

PROGRESS AND RESULTS

MGVD and ILD Transducer Susceptibility to Differences in Asphalt and Nonreinforced Concrete

Summary -- The measurements described below were made to assess the differences, if any, in the basic operation of an amplitude-optimized MGVD transducer and an ILD emplaced in nonreinforced concrete and asphalt roadways. Special instrumentation was assembled and tested at two locations in Minneapolis. The asphalt test site was located in a parking lot at Honeywell Inc., 2600 Ridgway Parkway, Minneapolis, Minnesota, and the nonreinforced concrete location was at the corner of N.E. Arthur Street and 18th Avenue N.E., also in Minneapolis.

The method of determining whether the transducers would operate differently in each of these two roadway mediums was to observe and measure the null signal levels, i.e., the no-vehicle-present level. If the transducer would have significantly different operating characteristics during a vehicle passage, then these characteristics would also appear as a change in the null signal levels.

No attempt was made to measure or determine absolute impedance values as in the ILD. Since the purpose of the test was to determine the difference in operation, the only requirement was that the method used to determine a null condition be consistent from test site to test site and have enough resolution to detect small changes in the measured parameters. These two requirements were achieved. As a result of these tests it was concluded that no significant differences exist between nonreinforced concrete and asphalt with regard to the operation of the MGVD and ILD transducers.

Instrumentation --

MGVD -- The tests were conducted with an amplitude-optimized transducer; therefore, no attempt was made to determine phase information.

The test configuration is illustrated in Figure 1. The receive and transmit triax cables were 50 feet each. The transmitter output amplitude was adjusted to 500 milliamperes peak-to-peak with a 50-ohm resistive load. The receive signal was put through a buffer transformer circuit which is a duplicate of the MGVD receiver input electronics. The 100-kHz signal levels were then read on the gain/phase meter and oscilloscope.

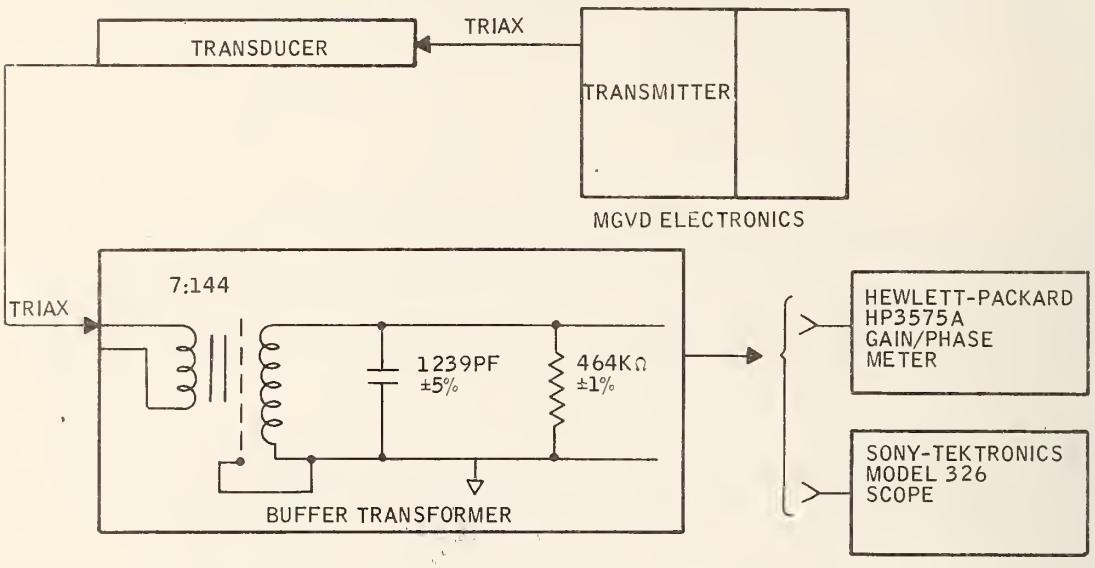


Figure 1. MGVD Instrumentation

ILD -- The ILD measurements were performed two ways. In both cases, however, the same loop was used. The first method was to connect a Decatur Electronics Model XLMK loop detector to the ILD and note the amount of capacitance required to tune the loop in each roadway medium. A change in loop impedance is reflected as a change in tuned capacitance at a fixed frequency. Since the capacitance can only be changed in discrete steps, however, this method is meant to be only a gross or backup means for the second method.

The second method of measuring an operational change between concrete and asphalt is to determine the resonant frequency change of the tuned ILD versus that of a fixed capacitance. Figure 2 illustrates this method. A Lissajous pattern was used to determine when resonance was achieved. In both roadway media, the Lissajous pattern was able to indicate resonance to a resolution of less than 100 Hz. Once resonance was achieved, the frequency was noted and compared for both roadway media.

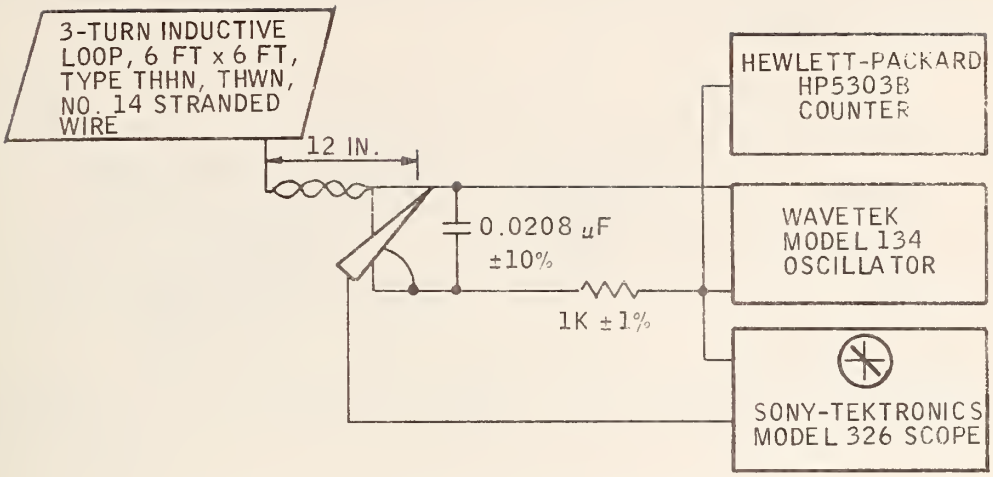


Figure 2. ILD Instrumentation

Both methods use the fact that, at resonance, the tuned circuit becomes purely resistive, i.e., the current and voltage are in-phase.

The ILD was fastened to the face of a wooden frame with nylon tie-cord to hold the wire in place. The frame was fastened with wooden dowels. During the tests, the frame was placed face down, i.e., with the loop wire in direct contact with the roadway.

Results -- Table 1 presents the data from the MGVD tests. The null voltage difference between the two media is only 0.2 millivolt or 11.5 percent. This is in contrast to the 32-millivolt signal level when an automobile is over the sensor. Therefore, the conclusion is that the transducer sees no appreciable difference between nonreinforced concrete and asphalt.

Table 1. MGVD Data

Medium	Condition without Vehicle	Condition with Vehicle
Asphalt	1.8 mv p-p -64.2 dBV	32 mv p-p -38.7 dBV
Nonreinforced concrete	1.6 mv p-p -64.9 dBV	Same car not available

Table 2 presents the data from the ILD tests (both methods). The resonant frequency method is discussed first.

Table 2. Inductive Loop Data

Medium	Resonant Frequency (kHz)	Decatur Model XLMK Detector Loop Switch Position
Asphalt	130.30	4/7/10 (33,190 pF)
Nonreinforced concrete	131.09	4/7/5 (33,690 pF)

First,

$$f_1 = \frac{0.159}{\sqrt{L_1 C_1}}$$

and

$$f_2 = \frac{0.159}{\sqrt{L_2 C_2}}$$

for a steady-state sinusoidal forced response. But, for this case,

$$C_1 = C_2$$

Therefore,

$$f_2 = \frac{0.159}{\sqrt{L_2 C_1}}$$

It follows, then, that

$$\frac{f_1}{f_2} = \frac{\frac{0.159}{\sqrt{L_1 C_1}}}{\frac{0.159}{\sqrt{L_2 C_1}}} = \frac{\sqrt{L_2 C_1}}{\sqrt{L_1 C_1}}$$

and

$$\left(\frac{f_1}{f_2}\right)^2 = \frac{L_2}{L_1}$$

Thus,

$$\frac{L_2}{L_1} = \left(\frac{130.30}{131.09}\right)^2 = 0.9879$$

From the above, it is demonstrated that there is less than 2 percent change in impedance between an ILD in asphalt versus one in nonreinforced concrete using this method.

Results of the second method are as follows:

$$f_1 = \frac{0.159}{\sqrt{L_1 C_1}}$$

and

$$f_2 = \frac{0.159}{\sqrt{L_2 C_2}}$$

But, for this case,

$$f_1 = f_2$$

Therefore,

$$\frac{0.159}{\sqrt{L_1 C_1}} = \frac{0.159}{\sqrt{L_2 C_2}}$$

and

$$L_1 C_1 = L_2 C_2$$

Thus,

$$\frac{L_2}{L_1} = \frac{C_1}{C_2} = \frac{33,190}{33,690} = 0.9851$$

This method also yields an impedance change between asphalt and nonreinforced concrete of less than 2 percent, which is in agreement with the results of the first method; i.e., there are no significant differences in ILD performance in asphalt or nonreinforced concrete.

Honeywell Vehicle Test Facility

The objective of the Honeywell Vehicle Test Facility is to enable vehicle detection and special vehicle classification systems to be developed and tested under controlled conditions. The facility, located at Honeywell Inc., 2600 Ridgway Parkway, Minneapolis, Minnesota, is instrumented with magnetic-type vehicle detectors and supporting instrumentation. The need for data from transducers mounted in reinforced concrete required installation of a special concrete section in the parking lot. To shelter test personnel and instrumentation from the weather, a small metal building with laboratory benches and power is included in the test facility. The location of the test facility is shown in Figure 3. Also shown are the concrete slab (square at center) and the lane markings extending 200 feet north-south and east-west from the slab.

Slab Dimensions and Lane Marker Detail -- Figure 4 illustrates the reinforced concrete slab and lane marker detail. The reinforced concrete slab is 24 feet by 24 feet by 6 inches thick. The slab is essentially at the same level at all edges with the asphalt paving surface.

Reinforcing Installation -- Figure 5 shows the detail of the steel fabric used for reinforcing the concrete slab. The steel fabric is commonly known as "6x6-W4 W4" which implies a 6-inch by 6-inch grid of No. 4 gauge wire. The wires are welded at their intersections. This steel fabric weighs 58 pounds per 100-square feet and is installed at a depth (from surface) of 2 to 2-1/2 inches.

Shelter -- The personnel and instrumentation shelter is a 100-square-foot metal implement building retailed by Sears Roebuck and Co. The shelter is specifically modified to provide an observation window and is also insulated and heated to provide at least a 70°F inside temperature when the outside air temperature is 5°F. Benches and electrical outlets for instrumentation are included. The shelter is securely attached to a wooden pallet which forms the floor.

Electrical requirements for the shelter are provided by two 20A, 115-VAC circuits. Power to the shelter is underground to a location adjacent to the shelter.

Vehicle Transducer Installation -- Figure 6 illustrates the vehicle transducer installation detail. In both the 24-foot by 24-foot reinforced concrete pad and asphalt, a 6-foot by 6-foot ILD is permanently installed according to highway

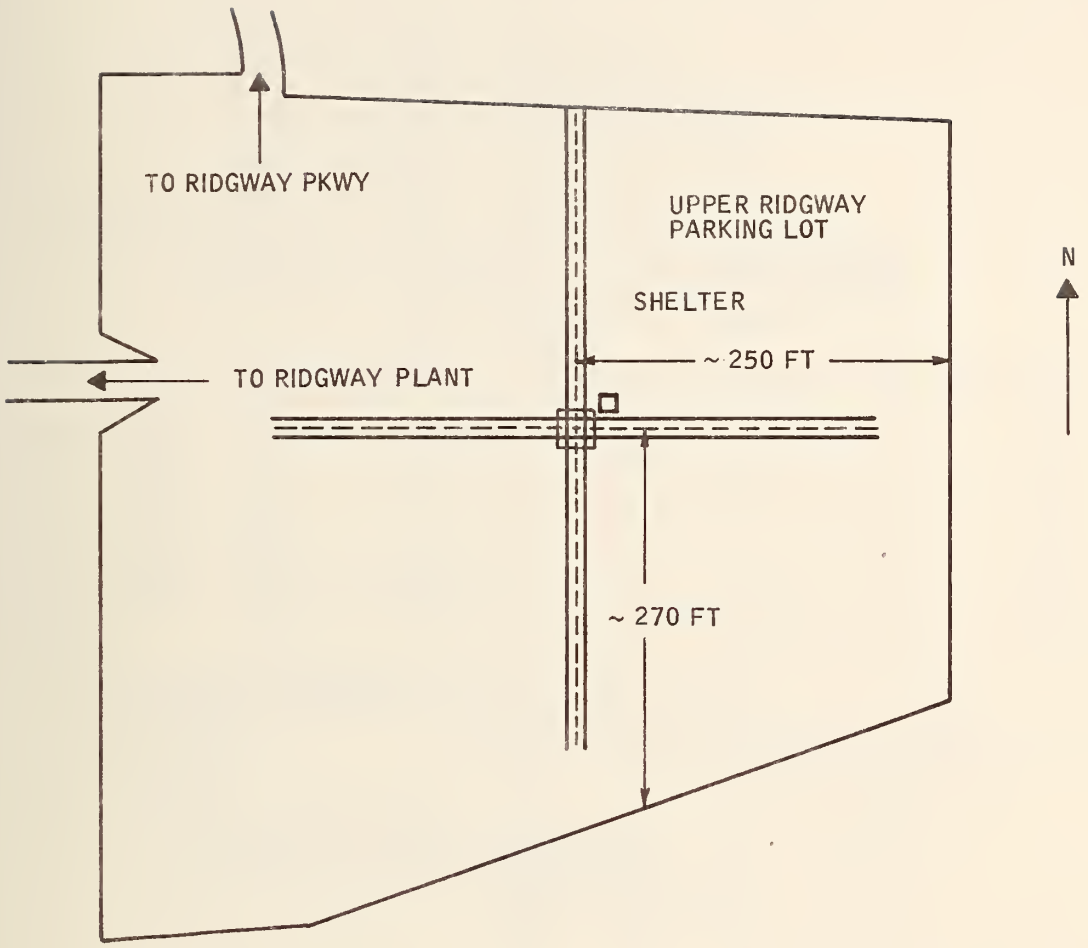


Figure 3. Test Bed Location

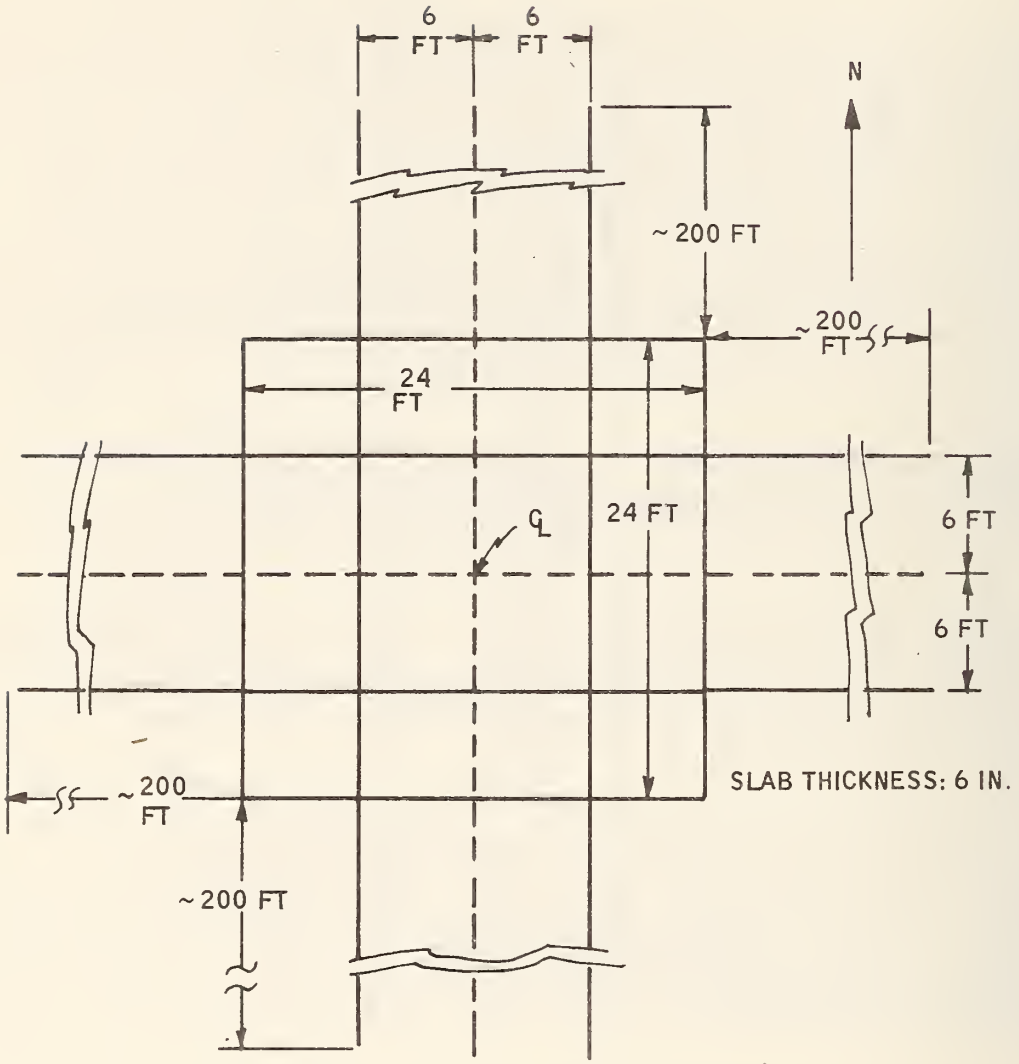


Figure 4. Slab Dimensions and Lane Marker Detail

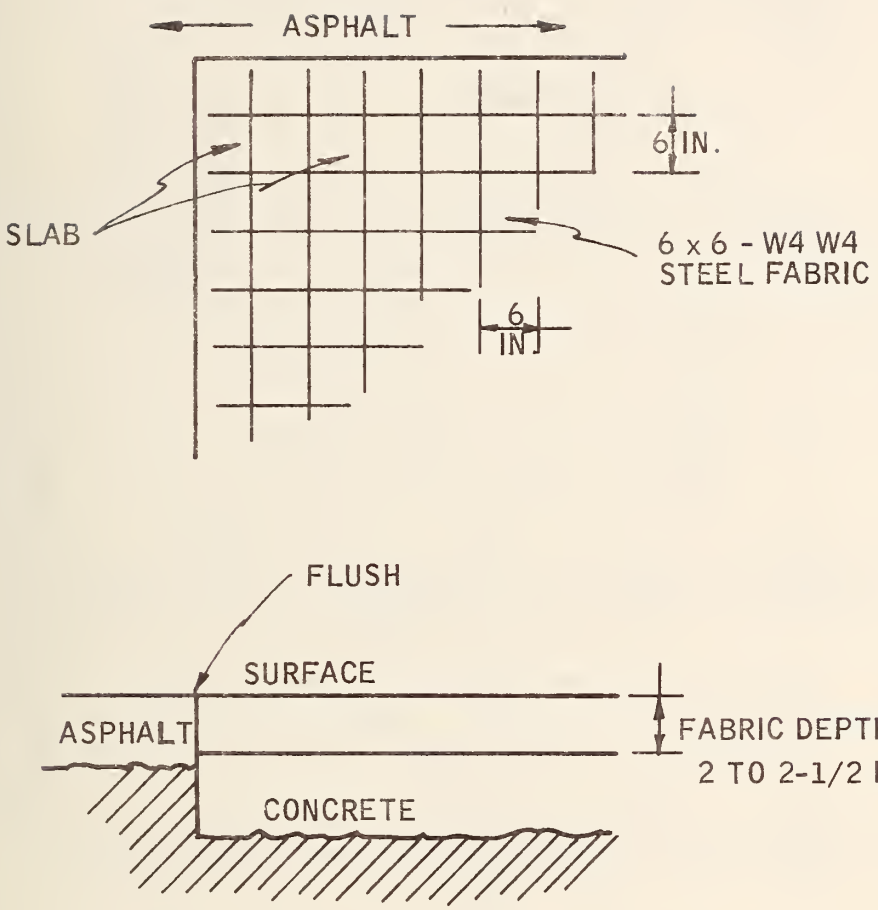


Figure 5. Steel Fabric Installation Detail

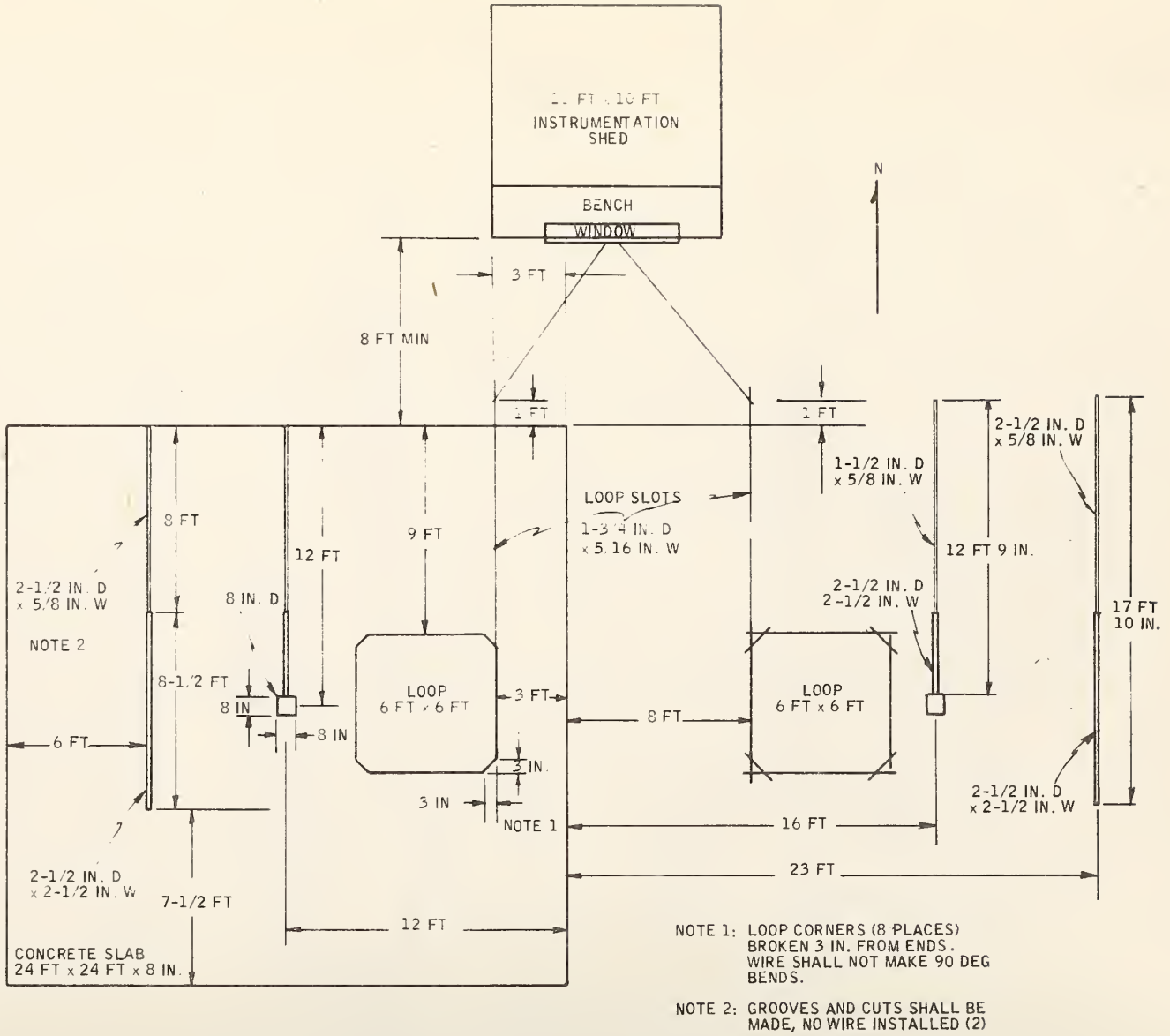


Figure 6. Bus Detector Test Pad Detail

specification. Adjacent to the ILD is an 8-inch-square hole which penetrates the depth of the paving material. This hole, with the wire raceway slots, is the location for installing the three-axis magnetometers. Adjacent to the magnetometer holes are the slots necessary to temporarily install the MGVD transducer.

All transducers have signal wire raceways of sufficient length and depth to ensure that the vehicles do not run over the signal wires. The raceways and temporary transducer locations have provisions for environmental covers when not in use.

Signature Acquisition

Deletion of Additional Magnetometer Signature Acquisition -- Federal Highway Administration Report No. FHWA-RD-7522 contains several hundred three-axis magnetometer signatures acquired during the Phase I self-powered vehicle detector (SPVD) portion of the vehicle detection contract. These signatures were acquired from several vehicle types, including an urban transit bus, tractor-trailer (semi), automobiles, and bicycle. Early in the bus detection portion of the vehicle detection contract, the magnetometer signatures of the urban transit bus were examined to determine if the magnetometer was a viable transducer candidate. Examination of bus features contained in the signatures revealed three things:

1) It may be possible to develop a bus classifier using the vertical magnetometer. However, the classifier would be severely affected by vehicle offset from the transducer centerline.

2) The magnetometer signature from each axis will vary with geographical location (e.g., the vertical magnetometer will have a higher output in Minneapolis than in Dallas).

3) The magnetometer signature from each axis will vary as a result of the proximity of metal, such as reinforcing rods, buried streetcar tracks, etc.

These three factors, combined with the bus detector performance design goals, caused serious concern on the practicality of using a magnetometer transducer for successful passive bus detection. As a result, additional vehicle signatures, over and above those presented in FHWA-RD-7522, were considered superfluous to the objectives of the signature acquisition effort.

ILD and MGVD Signature Acquisition -- To gather as much data as possible within time and financial resources of the project, the signature acquisition effort was divided into five areas, as follows:

1) Record, simultaneously, vehicle signatures using an amplitude-optimized MGVD and ILD, both in reinforced concrete.

2) Record, simultaneously, vehicle signatures using an amplitude-optimized MGVD and ILD, both in asphalt.

3) Record vehicle signatures using a phase-optimized MGVD in reinforced concrete.

4) Record vehicle signatures using a phase-optimized MGVD in asphalt.

5) Record any additional data as necessary to complete the signature library or to provide a greater statistical data for the bus classifier design.

Primary emphasis was given to data needed for the bus classifier design. After Phase I of the data acquisition effort, the signatures were analyzed for those vehicles which presented a difficult bus classifier problem. Subsequently, additional data were gathered on specific vehicles which were thought to provide signature characteristics similar to a bus.

The primary vehicle speed over the sensor was 10 mph. A limited amount of "stopped vehicle" data were taken, primarily on those vehicles of specific interest. Vehicle displacement with respect to the sensor was taken for three cases. First, the vehicle's centerline coincided with the centerline of the sensor. Next, the vehicle's centerline was displaced 3 feet from the sensor. Finally, the vehicle's centerline was displaced 6 feet from the sensor.

Vehicle Types (see Appendix A) -- Initial vehicle types used for signature acquisition were:

- Bus - GMC
- Bus - Flxible
- Large automobile
- Mid-size automobile
- Small automobile
- Motorcycle
- Bicycle
- Truck

Following acquisition of the Phase I signatures, additional vehicles were added which were thought to provide similar signatures to the two buses. These vehicles were:

- Tractor-trailer truck with "drop frame"
- Tractor-trailer truck
- Step-van

Late in the passive bus detector development, a small number of signatures was acquired from an A.M. General bus. These signatures, not presented herein, were acquired at the FHWA Fairbanks Research Station and were used only for verification of the bus classifier design.

Instrumentation -- Figure 7 shows the ILD/MGVD transducer/instrumentation test configuration used for acquiring the vehicle signatures. To retain as much signature "purity" as practical, instrumentation-grade equipment was used wherever possible. Phase and amplitude measurements from both the MGVD and ILD were made with a Hewlett-Packard HP3575A gain/phase meter. The transducers were driven by their respective electronics so as to lend a degree of real-worldness to the measurements. Tape recordings were made at 7.5 inches per second using FM record electronics. Tables 3, 4, and 5 detail the scale factors and instrumentation settings for the tests.

Signature Data -- Appendix B is the signature acquisition test log which describes the conditions for each test run. For the ILD data, all tests were conducted using a 50-foot lead-in unless otherwise noted. The information contained in Appendix B must be used to interpret the characteristics of the signature data. Appendix C contains all valid signatures acquired and recorded during the effort. Because of incorrect gain settings, Runs 1 through 79 are not presented. These runs were repeated during runs 80 through 180.

To derive signal amplitude and phase shifts from the signature data, the following equations are used (applicable for both the ILD and MGVD):

$$\text{Amplitude} = \left(\frac{\text{Amplitude scale factor}}{\text{Amplitude gain set}}\right) (\text{Strip-chart gain}) \text{ dBV/div}$$

$$\text{Phase} = \left(\frac{\text{Phase scale factor}}{\text{Phase gain set}}\right) (\text{Strip-chart gain}) \text{ deg/div}$$

The scale factors and strip-chart gains for both amplitude and phase were held constant throughout the tests; thus,

$$\text{Amplitude} = \left(\frac{10}{\text{Amplitude gain set}}\right) \text{ dBV/div}$$

$$\text{Phase} = \left(\frac{10}{\text{Phase gain set}}\right) \text{ deg/div}$$

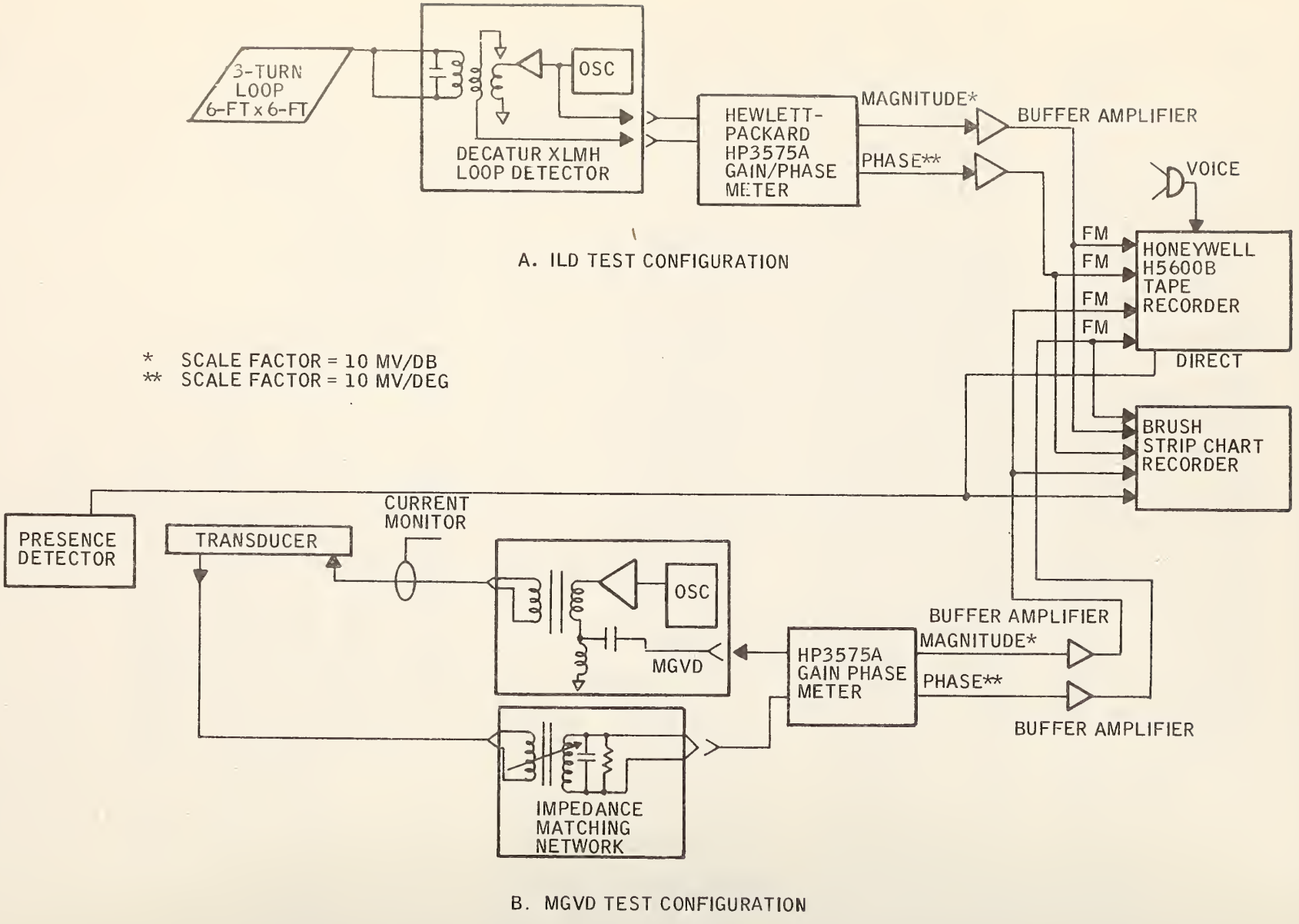


Figure 7. ILD/MGVD Transducer/Instrumentation Test Configuration for Acquiring Vehicle Signatures

Table 3. HP3575 Gain/Phase Meter Settings (Output Scale Factors are Amplitude: 1 dB = 10 mV, Phase: 1 deg = 10 mV)

Transducer	Channel A	Frequency (Hz)	Amplitude Function	Phase Reference	Channel B
ILD	2 mV - 20 V	1k - 13M	B	A	2 mV - 20 V
MGVD	2 mV - 20 V	1k - 13M	B	-A	0.2 mV - 2 V

Table 4. H5600B Tape Recorder Channel Assignments

Channel	Band	Frequency (kHz)	Transducer	Mode
1	---	---	---	---
2	Direct	---	Presence	---
3	FM	2.5	IRIG time code	---
4	FM	2.5	MGVD	Amplitude
5	FM	2.5	MGVD	Phase
6	FM	5.0	ILD	Amplitude
7	FM	5.0	ILD	Phase

Table 5. Strip-Chart Assignments

Channel	Gain (V/div)	Transducer	Mode
1	INOP (Off)	N/A	N/A
2	0.1	MGVD	Amplitude
3	0.1	MGVD	Phase
4	0.1	ILD	Amplitude
5	0.1	ILD	Phase
6	0.5	---	---

Appendix B contains all necessary amplitude and phase gain set data for the preceding equations.

The "amplitude-optimized" MGVD was used for all runs through 365. This transducer had virtually no phase response. An improved MGVD, having amplitude and phase response, was used for all runs after 366.

SECTION V
CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The vehicle signatures contained in this report are sufficient to develop a successful passive bus detector. The Honeywell Vehicle Test Facility and instrumentation techniques used for the signature acquisition activity proved to be an efficient and useful method of successfully obtaining true vehicle signature data under closely controlled conditions.

RECOMMENDATIONS

As microprocessor technology expands and continues to become a more cost-effective method of passively classifying vehicles in an urban traffic environment, additional signature data should be acquired to supplement the data in this report. Signature data analysis could then be used to develop a cost-effective vehicle classification system.

APPENDIX A
VEHICLE DESCRIPTIONS

VEHICLE DESCRIPTION

Vehicle

Type: Bus - MTC No. 247

Year: 1967

Mfgr: GMC

License No.: D311

Number of Axles: 2

Width Overall: 8' 4"

Length Overall: 40'

Wheel Base(s): 23' 10"

Max. Ground Clearance: 2'11"

Min. Ground Clearance: 11"

Average Ground Clearance: 2'

Max. Height: 9' 4"

Wheel Diameter (including tire): 3' 6"

Front Overhang: 7'

Rear Overhang: 9' 4"

Notes:

VEHICLE DESCRIPTION

Vehicle

Type Bus - MTC No. 883

Year 1974

Mfgr Flxible

License No. 621

Number of Axles 2

Width Overall 8' 6"

Length Overall 39' 9"

Wheel Base(s) 23' 8"

Max. Ground Clearance 3' 1"

Min. Ground Clearance 10"

Average Ground Clearance 2'

Max. Height 11'

Wheel Diameter (including tire) 3' 8"

Front Overhang 7' 1"

Rear Overhang 9' 1"

Notes:

VEHICLE DESCRIPTION

Vehicle

Type: Large Auto

Year: 1972

Mfgr: Ford LTD Wagon

License No.: BD2175

Number of Axles: 2

Width Overall: 6' 7"

Length Overall: 18' 1"

Wheel Base(s): 10' 1"

Max. Ground Clearance: --

Min. Ground Clearance: 8"

Average Ground Clearance: 10"

Max. Height: 4' 9"

Wheel Diameter (including tire): 2' 3-1/2"

Front Overhang: 3'5"

Rear Overhang: 4'10"

Notes:

VEHICLE DESCRIPTION

Vehicle

Type: Mid-Size Auto

Year: 1972

Mfgr: Ford Torino

License No.: EA7311

Number of Axles: 2

Width Overall: 6' 5"

Length Overall: 17' 0"

Wheel Base(s): 9' 10"

Max. Ground Clearance: --

Min. Ground Clearance: 6"

Average Ground Clearance: 8"

Max. Height: 4' 5"

Wheel Diameter (including tire): 2' 1"

Front Overhang: 3' 4"

Rear Overhang: 4' 0"

Notes:

VEHICLE DESCRIPTION

Vehicle

Type: Small Auto

Year: 1968

Mfgr: VW Bug

License No.: DF1282

Number of Axles: 2

Width Overall: 62"

Length Overall: 13' 3"

Wheel Base(s): 7' 11"

Max. Ground Clearance: --

Min. Ground Clearance: 7"

Average Ground Clearance: 8"

Max. Height: 4' 8"

Wheel Diameter (including tire): 2' 1"

Front Overhang: 2' 4"

Rear Overhang: 3' 0"

Notes:

VEHICLE DESCRIPTION

Vehicle

Type: Motorcycle

Year: 1974

Mfgr: Harley Davidson

License No.: 133603

Number of Axles: 2

Width Overall: 3'

Length Overall: 6' 7"

Wheel Base(s): 4' 1"

Max. Ground Clearance: 10"

Min. Ground Clearance: 6"

Average Ground Clearance: 10"

Max. Height: 4' 3"

Wheel Diameter (including tire): 2'2" (Front); 2'3" (Back)

Front Overhang: --

Rear Overhang: 1'5"

Notes:

VEHICLE DESCRIPTION

Vehicle

Type Bicycle

Year 1967

Mfgr Raleigh (Hercules)

License No. --

Number of Axles 2

Width Overall 1'8"

Length Overall 5'7"

Wheel Base(s) 3'4-1/2"

Max. Ground Clearance 2'7"

Min. Ground Clearance 10"

Average Ground Clearance 1'8"

Max. Height 3'5"

Wheel Diameter (including tire) 2'2"

Front Overhang --

Rear Overhang --

Notes: Steel Frame

VEHICLE DESCRIPTION

Vehicle

Type Straight Truck

Year 1973

Mfgr GMC

License No. YD8873

Number of Axles 2

Width Overall 7'9"

Length Overall 27'2"

Wheel Base(s) 17'

Max. Ground Clearance 3'6"

Min. Ground Clearance 1'

Average Ground Clearance 2'2"

Max. Height 11'8"

Wheel Diameter (including tire) 3'3-1/2"

Front Overhang 2'8"

Rear Overhang 7'10"

Notes:

VEHICLE DESCRIPTION

Vehicle

Type: Moving Van

Year: 1972

Mfgr: Chevrolet

License No.: PR1810

Number of Axles: 4

Width Overall: 8'

Length Overall: 5'

Wheel Base(s): 12'5" (Tractor)
26'6" (First Tandem)
4' (Between Tandems)

Max. Ground Clearance: 4'3"

Min. Ground Clearance: 1'3"

Average Ground Clearance: 1'7"

Max. Height: 13'

Wheel Diameter (including tire): 3'6" (Tractor); 2'8" (Rear Tandem)

Front Overhang: 2'5"

Rear Overhang: 5'10"

Notes: Gross Wt.: 43,000 lb
AVL: 31,734 lb
LaBelle
Allied Van Lines

VEHICLE DESCRIPTION

Vehicle

Type Semi-Trailer

Year 1971

Mfgr GMC 9500

License No. YE70-733

Number of Axles 4

Width Overall 7'8-1/2"

Length Overall 50'6"

Wheel Base(s) 12'8-1/2" (Tractor)
27'10" (Tractor Rear to First Tandem)
4'2" (Tandem to Tandem)

Max. Ground Clearance 3'11"

Min. Ground Clearance 9"

Average Ground Clearance 3'

Max. Height 12'5-1/2"

Wheel Diameter (including tire) 3'5"

Front Overhang 2'1"

Rear Overhang 4'0"

Notes: No. 388

VEHICLE DESCRIPTION

Vehicle

Type Step-Van

Year 1970

Mfgr Chevrolet

License No. YE61-078

Number of Axles 2

Width Overall 6'9"

Length Overall 23'9"

Wheel Base(s) 13'1"

Max. Ground Clearance 2'2"

Min. Ground Clearance 9-1/2"

Average Ground Clearance 1'3"

Max. Height 8'4"

Wheel Diameter (including tire) 2'7"

Front Overhang 2'10"

Rear Overhang 6'9"

Notes:

APPENDIX B

VEHICLE SIGNATURE ACQUISITION TEST LOG

Tape No. 1

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
1	0	Station Wagon	10	40	150	No Strip Chart Available		Asphalt	60°F inside, -63.5 dB, 21.6 deg
2	0		10	40	150				55°F outside, Monday, 14 Oct. 74
3	0		10	20	150				
4	0								
5	+3								
6	+3								
7	+6								
8	+6								
9	0								
10	+6				75				
11	-3				75				
12	-6				75				
13	0	Torino	10	20	150			Asphalt	
14	0								
15	+3								
16	+3								
17	+6								
18	+6								-20.6 deg, -63.4 dB, 60°F
19	-3								
20	-6								
21	-9								
22	0	VW	10	20	150			Asphalt	
23	0								
24	+3								
25	+3								
26	+6								
27	+6								
28	-3								
29	-6								
30	0	Bicycle	5-10	20	150			Asphalt	

Tape No. 1

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
31	+3	Bicycle	5-10	20	150	No Strip Chart Available		Asphalt	
32	+3	↓	↓	↓	↓	↓		↓	
33	+6								
34	+6								
35	-6								
36	-3	↓	↓	↓	↓			↓	
37	0	Motorcycle	10	20	150			Asphalt	
38	0	↓	↓	↓	↓			↓	
39	+3								
40	+3								
41	+6								
42	+6								
43	-3								
44	-6	↓	↓	↓	↓	↓		↓	
45	0	Bicycle	5-10	No Strip Chart Available		500	50	Asphalt	50°F outside, Tuesday, 15 Oct. 74 +6.6 dB, +0.3 deg, 60°F inside
46	0	↓	↓	↓		↓	↓	↓	
47	+3								
48	+3								
49	+6								
50	-3								
51	-3								
52	-6	↓	↓			↓	↓	↓	
53	0	Motorcycle	10			500	50	Asphalt	
54	0	↓	↓			↓	↓	↓	
55	+3								
56	+3								
57	+6								
58	-3								
59	-3								
60	-6	↓	↓	↓		↓	↓	↓	

Tape No. 1

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
61	0	VW	10	No Strip Chart Available		500	50	Asphalt	74°F inside, Tuesday, 15 Oct. 74 +7.2 dB, +0.7 deg, 60°F outside
62	0								
63	+3								
64	+6								
65	-3								
66	-6								
67	0	Torino	10			500		Asphalt	
68	0						20		+7.3, +0.9 deg
69	0								
70	+3								
71	+6								
72	-3								
73	-6								
74	0	Station Wagon	10			500	20	Asphalt	
75	0								
76	+3								
77	+6								
78	-3								
79	-6								

Tape No. 2

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
80	0	Motorcycle	10	7	50	150	7	Asphalt	Inside temp = 84°F Outside temp = 67°F
81	0								
82	+3								ILD gain = +11.6 dB ILD phase = -0.3 deg
83	+6								
84	-3								MGVD gain = -66.0 dB MGVD phase = -33.0 deg
85	-6			7	50	150	7		
86	0			7	1	500	25		Two riders on motorcycle for Run 90
87	0		10						
88	+3		15						
89	+6		10						
90	0		10						
91	0	Bicycle	10	7	50	500	25		MGVD phase = -34.7 deg
92	0								ILD gain = 11.8 dB
93	+3								
94	+6								
95	-3								
96	-6								
97	0			7	1	500	25		
98	0			7	1	500	25		
99	0	Bus		7	50	150	7		Flxible Bus
100	0								Outside temp = 65°F
101	0								
102	+3								
103	+6								
104	-3								
105	-6								
106	+6			7	1	150	7		
107	-9			7	50	150	7		

Tape No. 3

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
108	0	Bus	10	7	50	150	7	Rein-forced concrete	Inside temp = 85°F
109	0								
110	0								MGVD phase = 34.0 deg MGVD gain = 41.6 dB
111	+3								
112	+6								ILD phase = 0.0 deg ILD gain = 8.7 dB
113	-3								
114	-6								
115	0		Stop						
116	0		Stop						
117	0		Stop						
118	0		Stop						
119	0	VW	10	7	50	150	7		Flxible bus Outside temp = 79°F
120	0								
121	+3								MGVD phase = 32.9 deg MGVD gain = -41.3 dB
122	+6								
123	-3								
124	-6								
125	0	Torino	10	7	50	150	7		ILD phase = -0.1 deg ILD gain = +8.8 dB
126	0								
127	+3								
128	+6								
129	-3								
130	-6								
131	0	Station Wagon	10	7	50	150	7		MGVD phase = 32.2 deg MGVD gain = -41.1 dB
132	0								Runs 115-118 chart speed is 5 mm/sec
133	0								
134	+3								
135	+6								
136	-3								
137	-6								

Tape No. 2

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
138	0	VW	10	7	50	150	7	Asphalt	Inside temp = 65°F Outside temp = 45°F
139	0								
140	+3								
141	+6								
142	-3								
143	-6								MGVD gain = -64.7 dB
144	0								MGVD phase = +2.7 deg
145	+3								
146	+6								ILD gain = 10.9 dB
147	-6				1				ILD phase = 0.0 deg
148	0	Torino	10	7	50	150	7	Asphalt	
149	0								
150	+3								
151	+6								
152	-3								
153	-6				1				Current on MGVD had to be turned down from 550 mA p-p initially.
154	+3				1				
155	+6				1				
156	0				1				
157	0	Station Wagon	10	7	50	150	7	Asphalt	
158	0								
159	+3								
160	+6								Outside temp = 49°F
161	-3								
162	-6								
163	-3				1				
164	-6				1				

Tape No. 2

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
165	0	Semi	10	7	50	150	7	Asphalt	Inside temp = 70°F Outside temp = 54°F
166	0	↓	↓	↓	↓	↓	↓	↓	
167	+3					↓			
168	+6(8)					500			MGVD gain = 64.4 dB MGVD phase = -15.8 deg
169	-3					↓			
170	-6(4)				↓				
171	+6				1				
172	+6	↓	↓	↓	1	↓	↓	↓	ILD gain = 6.6 dB ILD phase = -0.8 deg

Tape No. 3

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
173	0	Semi	10	7	50	150	7	Reinforced Concrete	
174	0	↓	↓	7	50	150	7	↓	
175	+3			7	50	500	25		MGVD gain = -37.5 dB
176	+6			↓	↓	↓	↓		MGVD phase = -16.3 deg
177	-3								
178	-6								
179	-6			7	↓	↓	↓		
180	+6	↓	↓	16	50	500	25	↓	ILD gain = 3.7 dB ILD phase = 0 deg

Tape No. 3

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
181	0	Motorcycle	10	7	50	150	7	Reinforced Concrete	Inside temp = 83°F
182	0								Outside temp = 70°F
183	+3								
184	+6								
185	-3								
186	-6								MGVD gain = -40.3 dB
187	0			16	100	500	25		MGVD phase = -32.3 deg
188	+3								
189	+6								
190	-3								ILD gain = +4.2 dB
191	-6								ILD phase = -0.4 deg
192	0	Bicycle							
193	0								
194	+3								
195	+6								
196	-3								
197	-6								
198	0	Truck		7	50	150	7		
199	0			7	50	500	25		
200	0								
201	+3								
202	+6								
203	-3								
204	-6								

Tape No. 2

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
205	0	Truck	10	7	50	500	25	Asphalt	Inside temp = 84°F Outside temp = 70°F
206	0								
207	0								MGVD phase = 34.0 deg MGVD gain = -65.1 dB
208	0								
209	+3								ILD phase = 0.3 deg ILD gain = +7.5 dB
210	+6								
211	-3								
212	-6								
213	0			7	1	150	7		
214	+6			7	1	150	7		
215	-6			7	1	150	7		
216	0	GMC Bus	10	7	50	150	7	Asphalt	Inside temp = 78°F Outside temp = 65°F
217	0								
218	0								MGVD phase = -31.10 deg MGVD gain = -65.3 dB
219	0								
220	+3		NO VOICE RECORDED ON MAG. TAPE						ILD phase = +0.2 deg ILD gain = +7.1 dB
221	+6								
222	-3								
223	-6								
224	Stop								
225	Stop								
226									No strip recordings for Runs 226, 227, 228 and 229.
227									
228									
229									

Tape No. 3

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
230	0	GMC Bus	10	7	50	150	7	Reinforced Concrete	Inside temp = 80°F Outside temp = 66°F
231	0	↓	↓	↓	↓	↓	↓	↓	MGVD phase = -32.2 deg MGVD gain = -40.4 dB
232	+3								
233	+6								
234	-3								ILD phase = -0.2 deg
235	-6								ILD gain = +4.1 dB
236	Stop								

Tape No. 4

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
237	0	GMC Bus	10	7	50	150	7	Asphalt	Inside temp = 76°F Outside temp = 66°F
238	0								
239	+3								MGVD phase = -32.1 deg MGVD gain = -65.3 dB
240	+6								
241	-3								ILD phase = +4.0 deg ILD gain = +7.5 dB
242	-6								
243	Stop								
244	0	Moving Van	10	7	50	500	7	Asphalt	-64.7 dBV, +1.7 deg MGVD +6.6 dBV, -0.5 deg ILD
245	0								
246	0								(244 and 245 no chart available; also 248)
247	0								
248	-6								
249	-6								
250	+6								
251	+6								
252	-6								
253	0							Rein-forced Concrete	Inside temp = 70°F Outside temp = +35°F
254	0								
255	+6								-36.1 dBV, +4.0 deg, MGVD +3.7 dBV, 0.4 deg ILD
256	+6								
257	-6								
258	-6								
259	-6			16			25		
260	+6			16			25		

Tape No. 4

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
261	0	Van	10	7	50	150	7	Reinforced Concrete	Inside temp = 74°F Outside temp = 40°F
262	0			16	50	500	25		
263	0								MGVD phase / -8.6 deg MGVD amplitude = 37.0 dB
264	+3								
265	+6								ILD phase = +0.2 deg ILD amplitude = +3.5 dB
266	+3								
267	-6								(No chart for run 284)
268	-6								
269	-6								
270	0	Van	Start/ Stop	16	50	500	25	Reinforced Concrete	
271	0								
272	+2								
273	+2								
274	+4								
275	+4								
276	-2								
277	-2								
278	-4								
279	-4								
280	0	Van	Load/ Stop	16	50	500	25	Reinforced Concrete	Runs 280 - 285 chart speed is 5 mm/sec
281	0								
282	+2								
283	-2								
284	-4								No chart for Run 284
285	-5								

Tape No. 4

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
286	0	Van	10	7	50	150	7	Asphalt	Inside temp = 80°F Outside temp = 49°F
287	0					500			
288	0								MGVD phase = - 15.5 deg MGVD amplitude = -64.9 dB
289	+3								
290	+6								ILD phase = 0.4 ILD amplitude = +7.3 dB
291	-3								
292	-6								
293	0								
294	-6				1				
295	0	Van	Start/ Stop/ Load	7	50	500	7	Asphalt	Runs 295 - 305 chart speed is 5 mm/sec
296	0								No chart for run 304
297	+2								
298	+2								
299	+4								
300	+4								
301	-2								
302	-2								
303	-4								
304	-4								
305	-4								

Tape No. 4

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
306	0	Van	2	7	50	150	7	Asphalt	Inside temp = 75°F Outside temp = 59°F
307	+3	↓	↓	↓	↓	↓	↓	↓	MGVD phase = -26.7 deg MGVD amplitude = -65.5 dB
308	+6	↓	↓	↓	↓	↓	↓	↓	
309	-3	↓	↓	↓	↓	↓	↓	↓	ILD phase = -0.6 deg
310	-6	↓	↓	↓	↓	150	↓	↓	ILD amplitude = +7.4 dB
311	0	Van	5	7	50	500	7	Asphalt	
312	+3	↓	↓	↓	↓	↓	↓	↓	
313	+6	↓	↓	↓	↓	↓	↓	↓	
314	-3	↓	↓	↓	↓	↓	↓	↓	
315	-6	↓	↓	↓	↓	↓	↓	↓	
316	0	Van	15	7	50	500	7	Asphalt	
317	+3	↓	↓	↓	↓	↓	↓	↓	
318	+6	↓	↓	↓	↓	↓	↓	↓	
319	-3	↓	↓	↓	↓	↓	↓	↓	
320	-6	↓	↓	↓	↓	↓	↓	↓	
321	-6 → +6	Van	5	7	50	500	7	Asphalt	
322	+6 → -6	Van	5	7	50	500	7	Asphalt	

Tape No. 5

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
323	0	Van - VW	10	7	50	500	7	Asphalt	
324	0	Van - VW	↓	↓	↓	↓	↓	↓	
325	0	VW - Van							
326	0	VW - Van							
327	0	VW - Van	10/Stop	7	50	500	7	Asphalt	
328	0	VW - Van	↓	↓	↓	↓	↓	↓	
329	0	Van - VW							
330	0	Van - VW							
331	0 - 9	VW - Van							
332	0 - 9	Van - VW							

Tape No. 6

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
333	0	Flxible Bus	5	---	---	500	7	Asphalt	Inside temp = 68°F Outside temp = 50°F
334	0			---	---				
335	0			---	---				
336	+3			---	---				ILD amplitude = +6.4 dB ILD phase = -0.6 deg
337	+6			---	---				
338	-3			---	---				
339	-6			---	---				No chart for Run 333
340	0		10	---	---				
341	+3		10	---	---				
342	-3		10	---	---				Flxible Bus No. 343, License No. D27
343	0		15	---	---				
344	+3		15	---	---				
345	-3		15	---	---				
346	- to +		5	---	---				
347	- to +			---	---				
348	+ to -			---	---				
349	+ to -			---	---				
350	+2			---	---				
361	+2			---	---				
352	+4			---	---				
353	-2			---	---				
354	-4			---	---				
355	Opp "0"			---	---				
356	Opp "3"			---	---				
357	Opp "-3"			---	---				
358	0		Stop/Go	---	---				
359	0		Stop/Go	---	---				

Tape No. 6

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	MGVD		ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
360	0	VW	10	---	---	500	7	Asphalt	Inside temp = 70°F Outside temp = 52°F
361	0	↓	↓	---	---	↓	↓	↓	
362	+3			---	---				
363	+6			---	---				ILD amplitude = +6.6 dB ILD phase = +0.4 deg
364	-3			---	---				
365	-6			---	---				

Tape No. 5

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	Phase-Optimized MGVD		FM ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
366	0	VW	10	7	50	150	7	Asphalt	Inside temp = 74°F Outside temp = 33°F
367	0				1	500			
368	0				1				MGVD amplitude = -60.9 dB MGVD phase = -42.0 deg
369	+3								
370	+6								
371	-3								ILD amplitude = +11.6 dB ILD phase = 0.2 deg
372	-6								
373	0	Ford Station Wagon	10	7	1	500	7	Asphalt	
374	0								Roadway conditions: Snow/Ice
375	+0								
376	+3								
377	+6								
378	-3								
379	-6								
380	0	Van	10	7	1	500	7	Asphalt	
381	0								
382	0								
383	+3								
384	+6								
385	-3								
386	-6								
387	0	Flxible Bus	10	7	1	500	7	Asphalt	Flxible Bus No. 895, License No. 850523, Year April 1974
388	0								
389	0								
390	+3								
391	+6								
392	-3								
393	-6								
394	-6								

Tape No. 5

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	Phase-Optimized MGVD		FM ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
395	0	VW	10	7	1	70		Asphalt	Ch 1 = MGVD amplitude Ch 2 = MGVD phase Ch 5 = ILD frequency Ch 7 = Presence
396	0						---		
397	+3						---		
398	+3						---		
399	+6						---		
400	+6						---		19 May 1975 Inside temp = 80°F
401	-3						---		
402	-3						---		
403	-6						---		
404	-6						---		MGVD amplitude = -62.2 dB MGVD phase = -37.7 deg
405	0		5				---		
406	0		15				---		
407	0	Van	10	7	1	70	---	Asphalt	
408	0						---		
409	+3						---		
410	+3						---		
411	+6						---		
412	+6						---		
413							---		
414	-3						---		
415	-6						---		
416	-6						---		
417	0		5				---		
418	0		15				---		
419	0	Station Wagon	15	7	1	70	---	Asphalt	MGVD phase = -43.4 deg MGVD amplitude = -63.2 dB
420	0						---		
421	+3						---		
422	+3						---		
423	+6						---		
424	+6						---		

Tape No. 5

Vehicle Signature Acquisition Test Log

Run No.	Displacement (ft)	Vehicle Type	Vehicle Speed (mph)	Phase-Optimized MGVD		FM ILD		Roadway Medium	Remarks
				Amplitude Gain Set	Phase Gain Set	Amplitude Gain Set	Phase Gain Set		
425	-3	Wagon	10	7	1	70	---	Asphalt	
426	-3						---		
427	-6						---		
428	-6						---		
429	0		5				---		
430	0	VW	10	7	1	70	---	Asphalt	350-ft lead-in on loop
431	+3						---		
432	+6						---		
433	-3						---		
434	-6						---		
435	0	Van	10	7	1	70	---	Asphalt	
436	+3						---		
437	+6						---		
438	-3						---		
439	-6						---		
440	0	Flxible Bus No. 897	10	---	---	70	---	Asphalt	
441	+3			---	---		---		
442	+6			---	---		---		
443	-3			---	---		---		
444	-6			---	---		---		
445	0			---	---		---		50-ft lead-in on loop
446	+3			---	---		---		
447	+6			---	---		---		
448	-3			---	---		---		
449	-6			---	---		---		

APPENDIX C
VEHICLE SIGNATURES

Runs 80-332

From top to bottom:

Trace 1 = MGVD amplitude

Trace 2 = MGVD phase

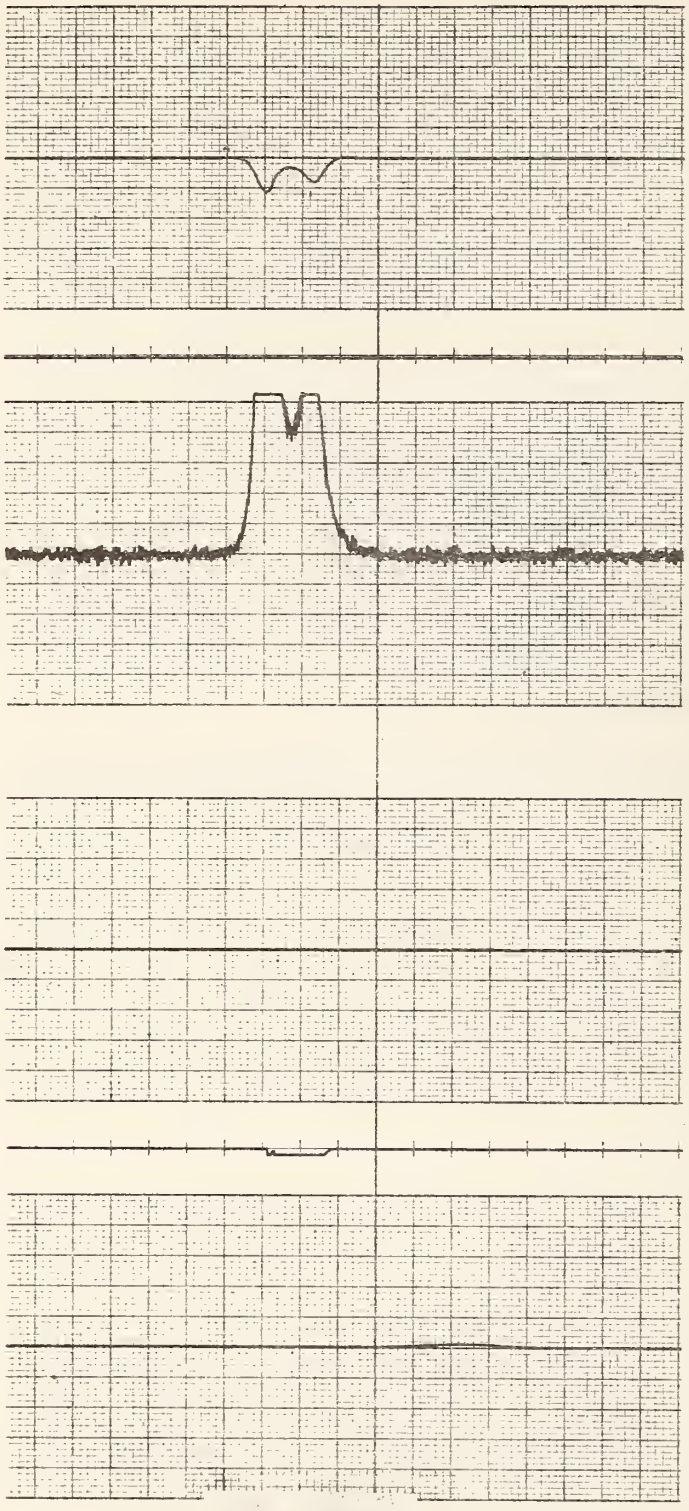
Trace 3 = ILD amplitude

Trace 4 (Marker) = Optical presence detector

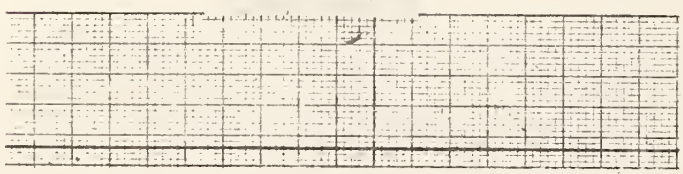
Trace 5 = ILD phase

Trace 6 = N/A

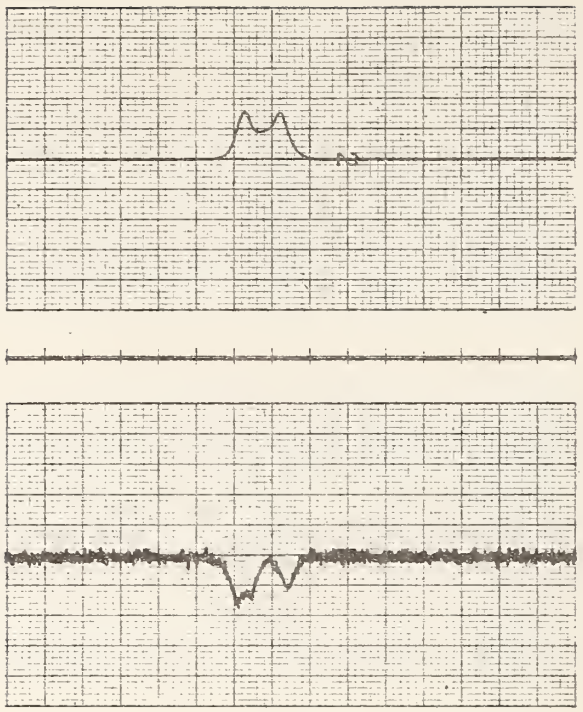
Chart speed = 25 mm/sec, except where noted in log book (Appendix B)



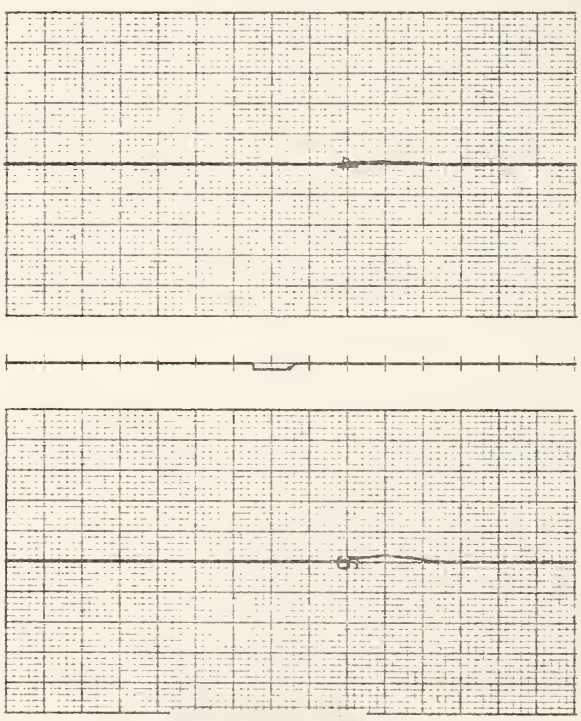
RUN 80



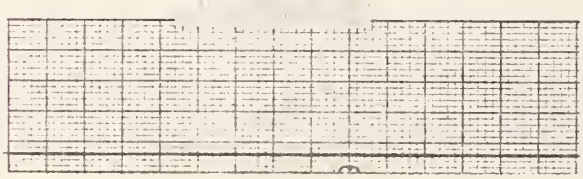
RUN 81

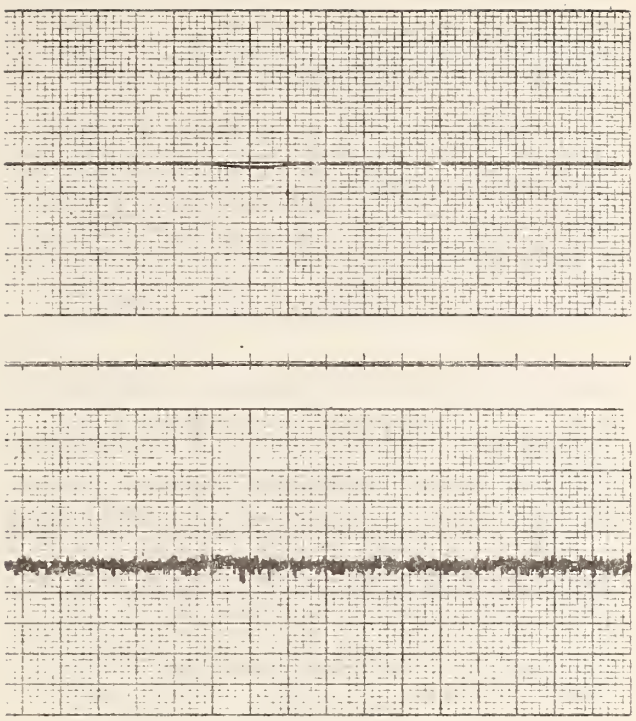


BRUSH ACCUCHART



RUN 68





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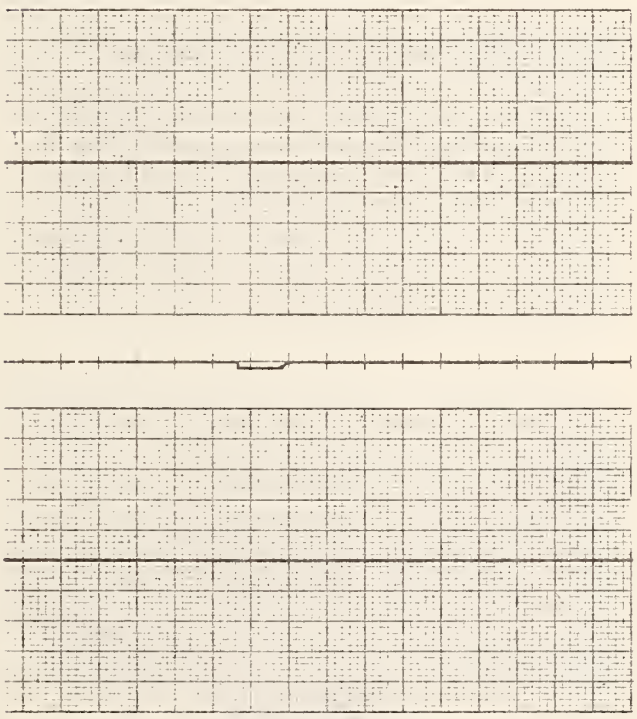
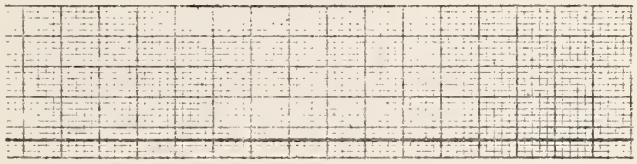
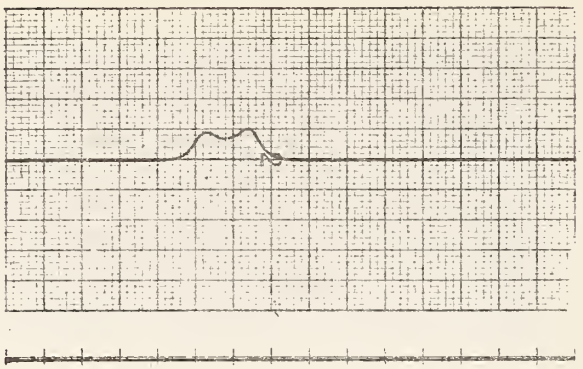
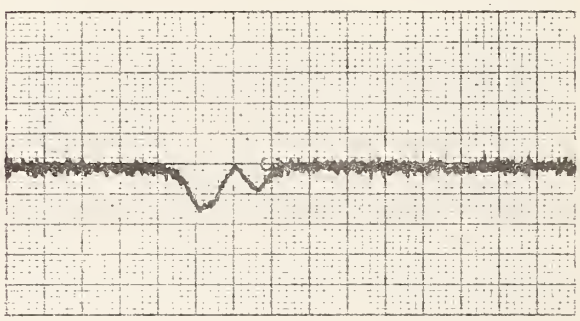
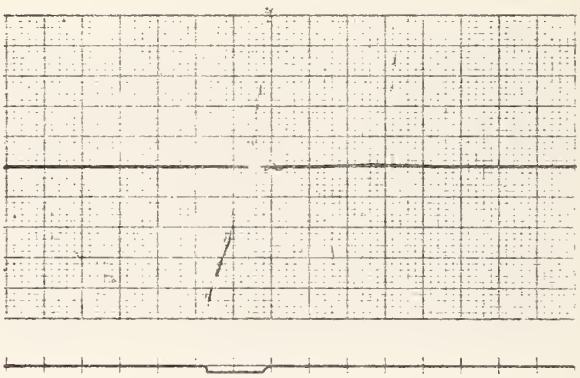


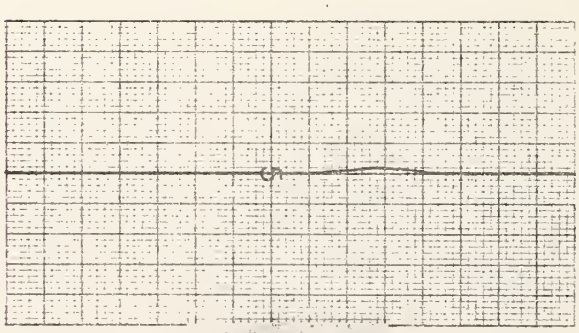
RUN 83

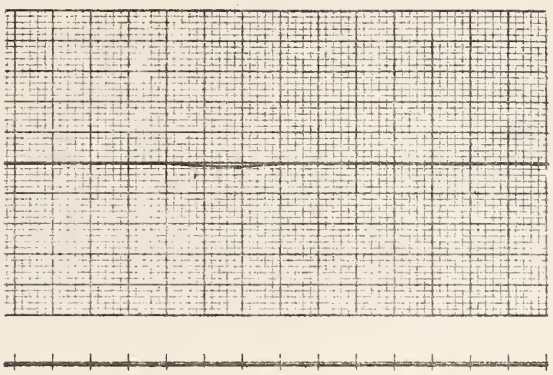


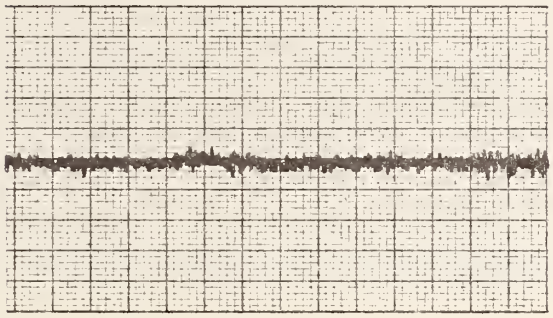


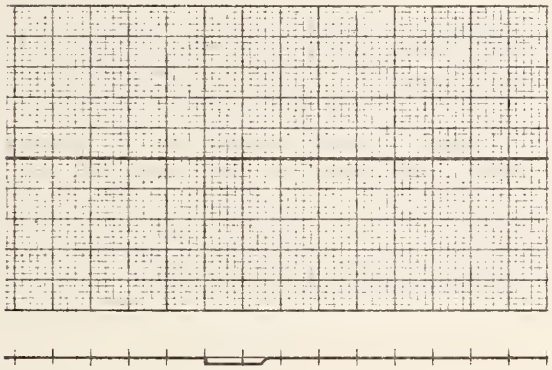


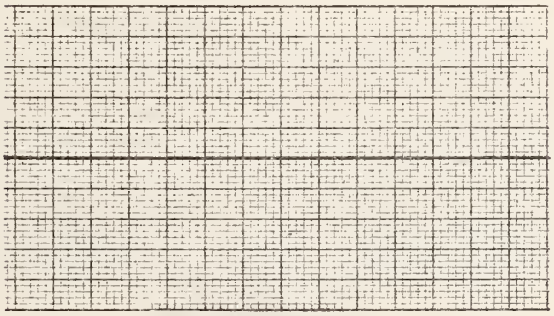












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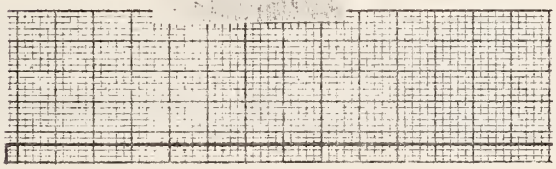

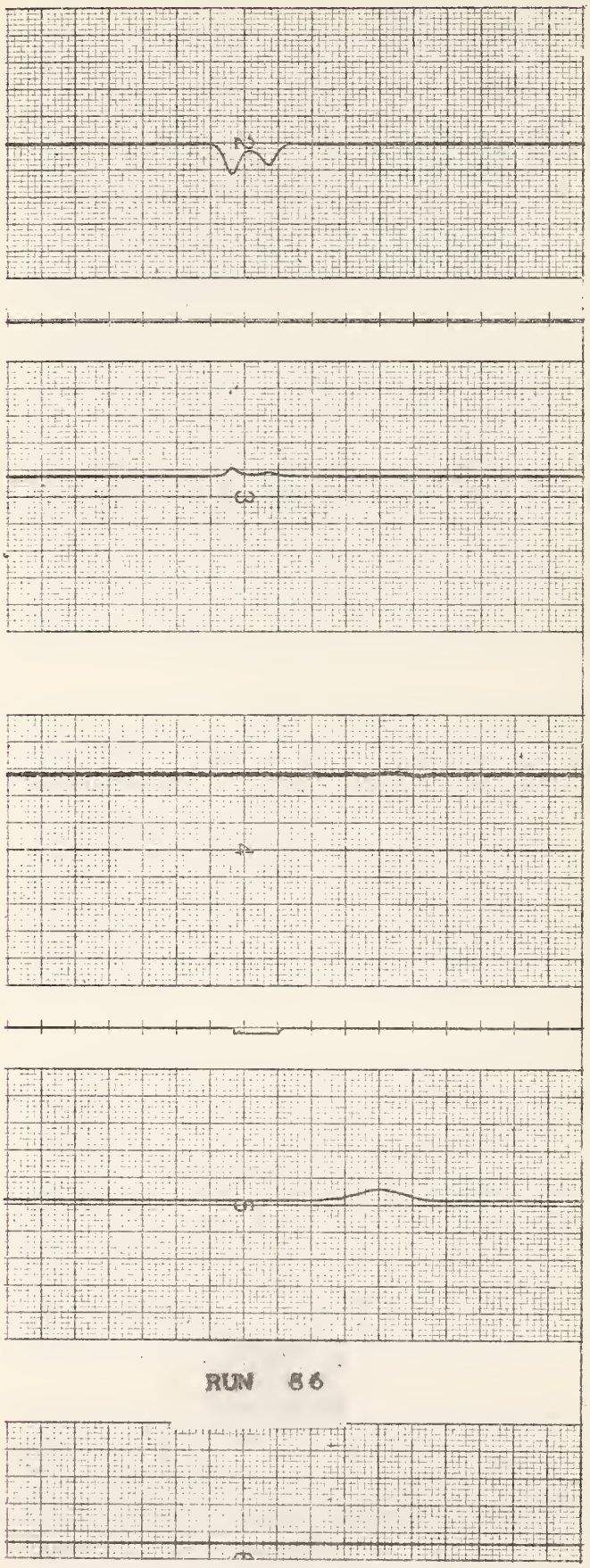
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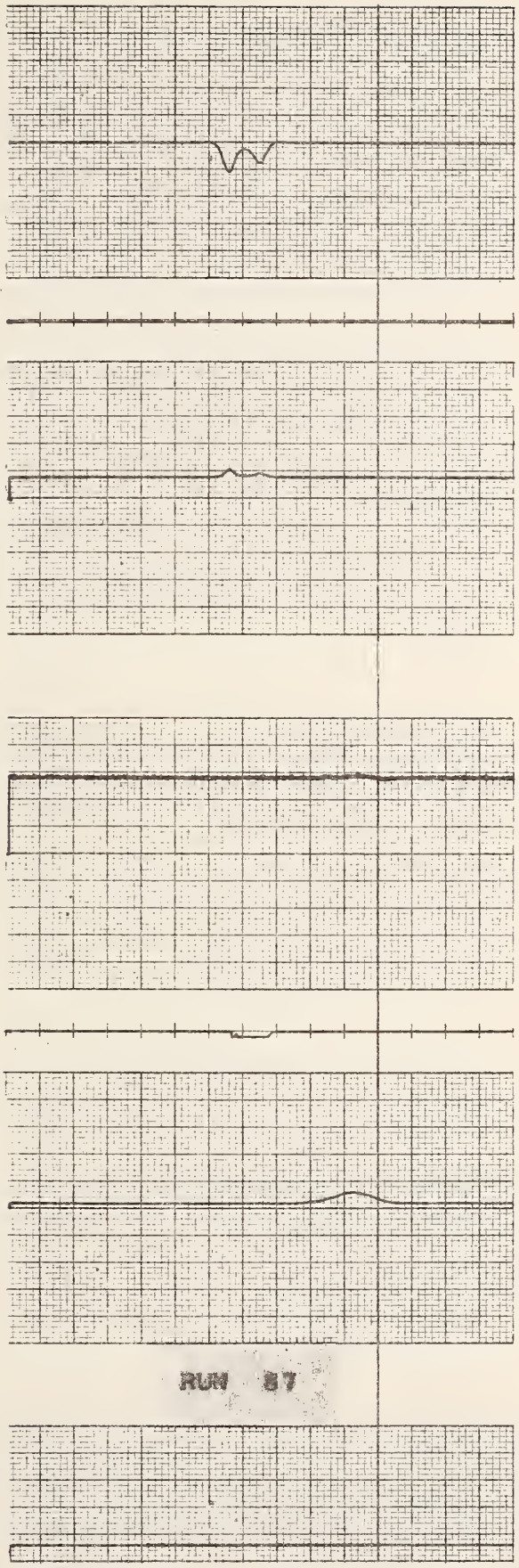
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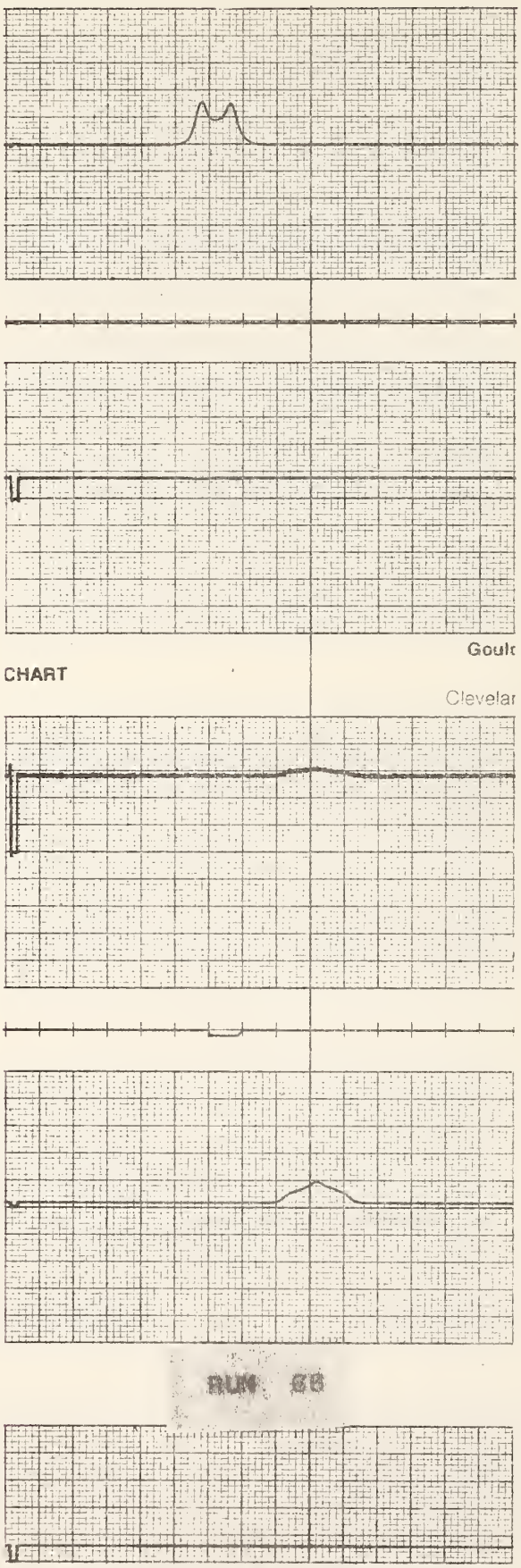
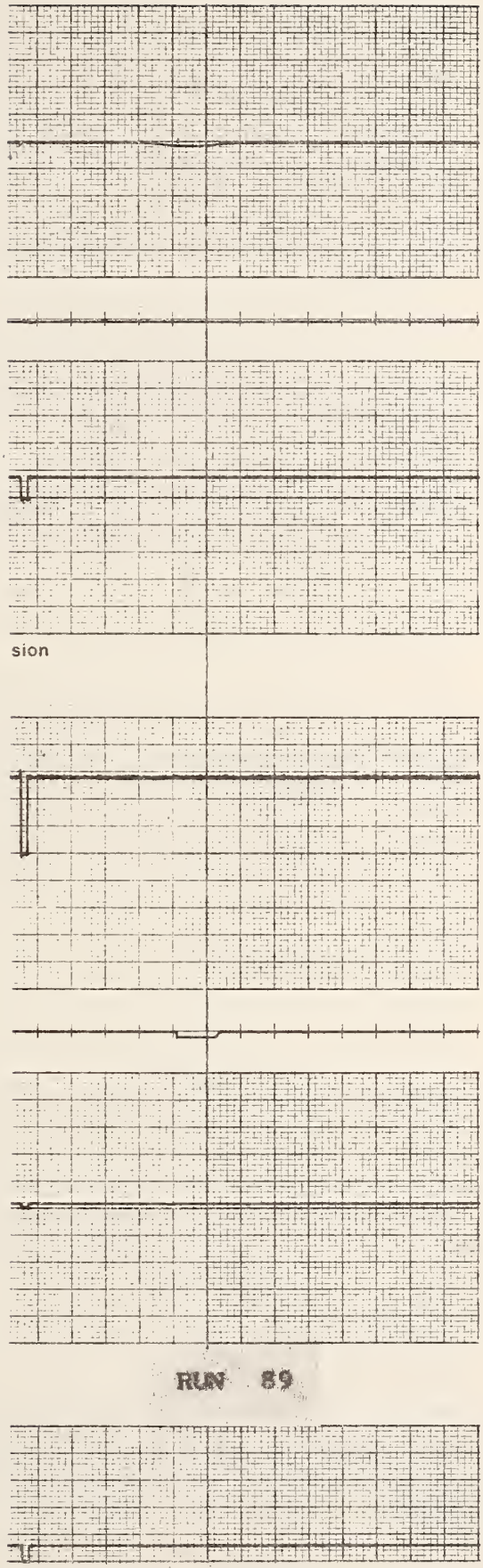
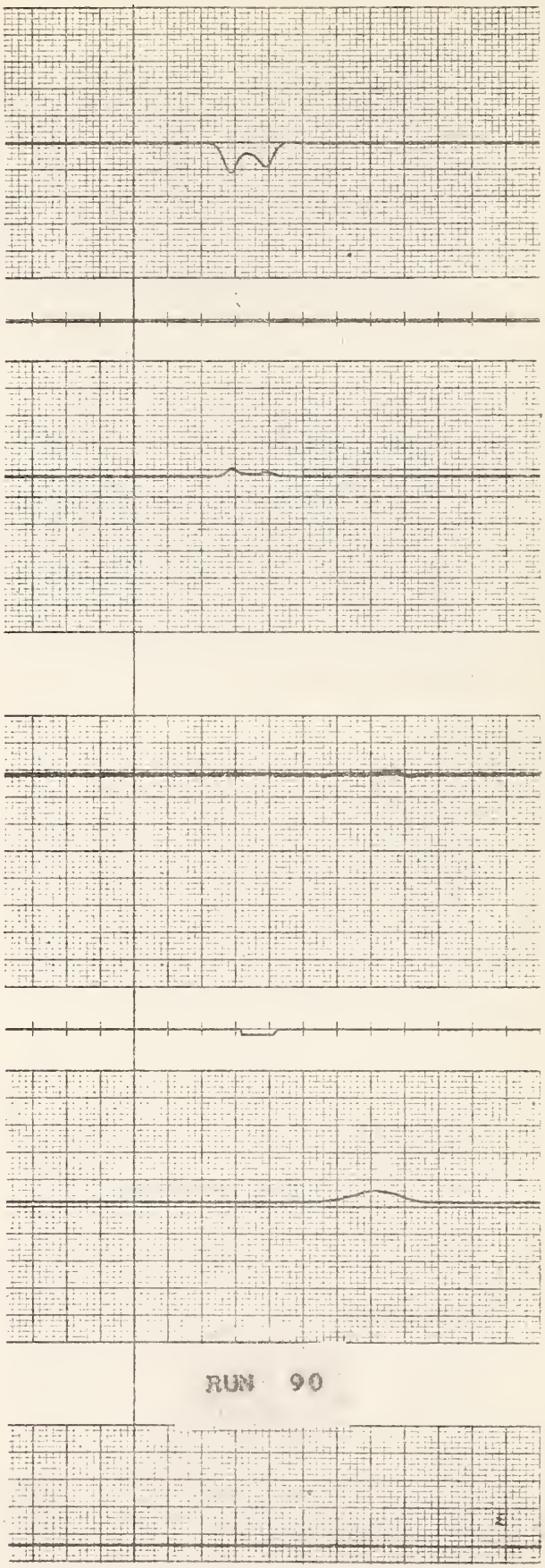

Goulc
CHART
Clevelar
RUN 68



sion

RUN 89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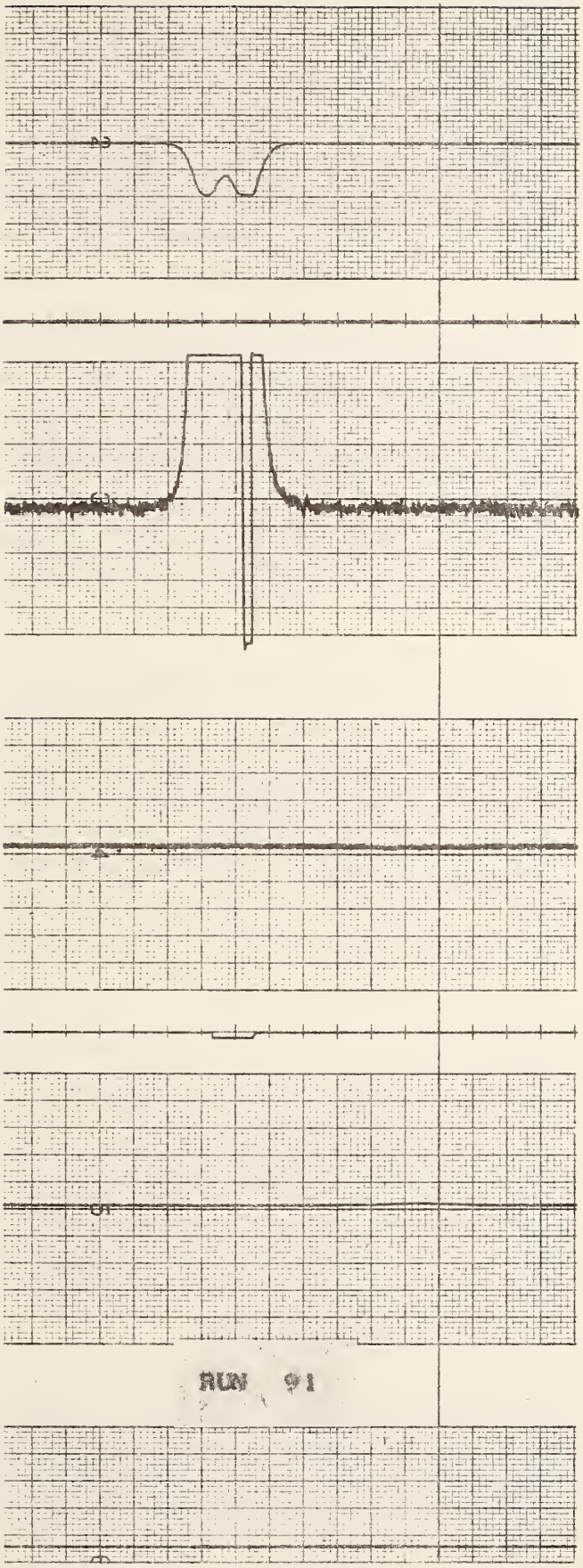

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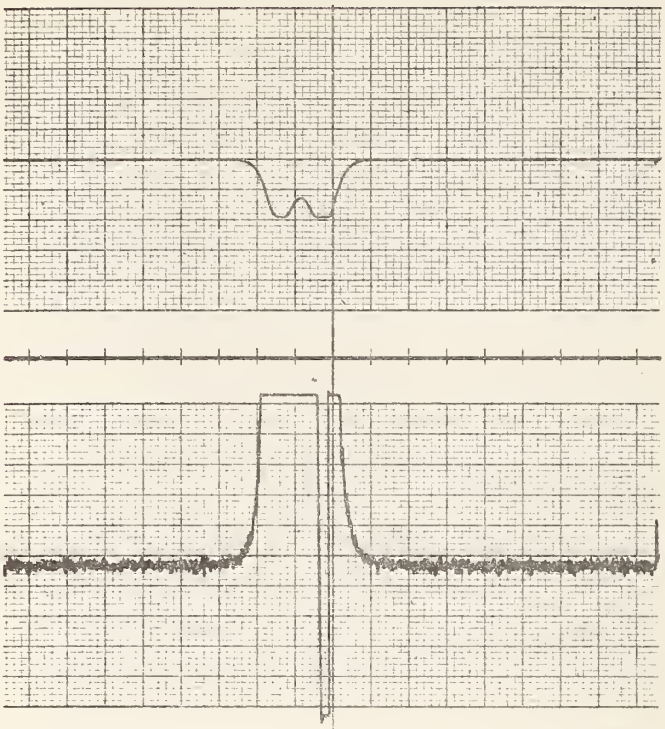

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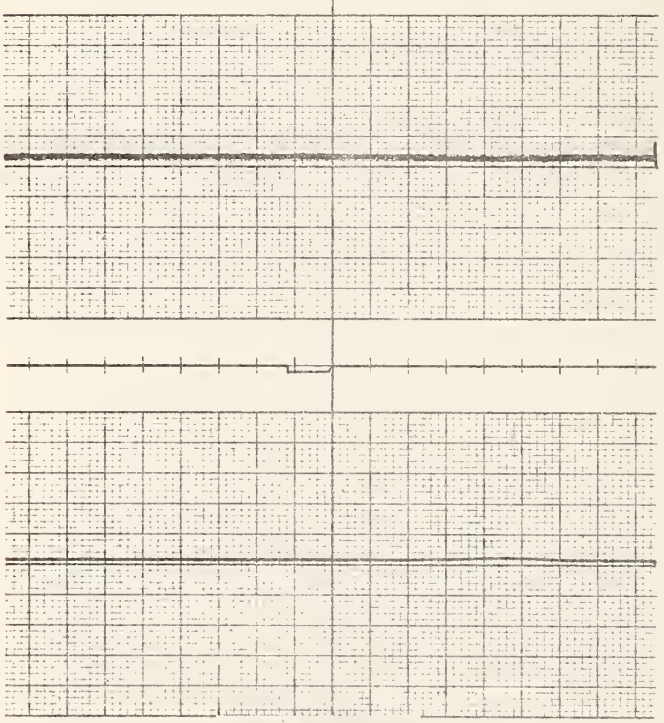

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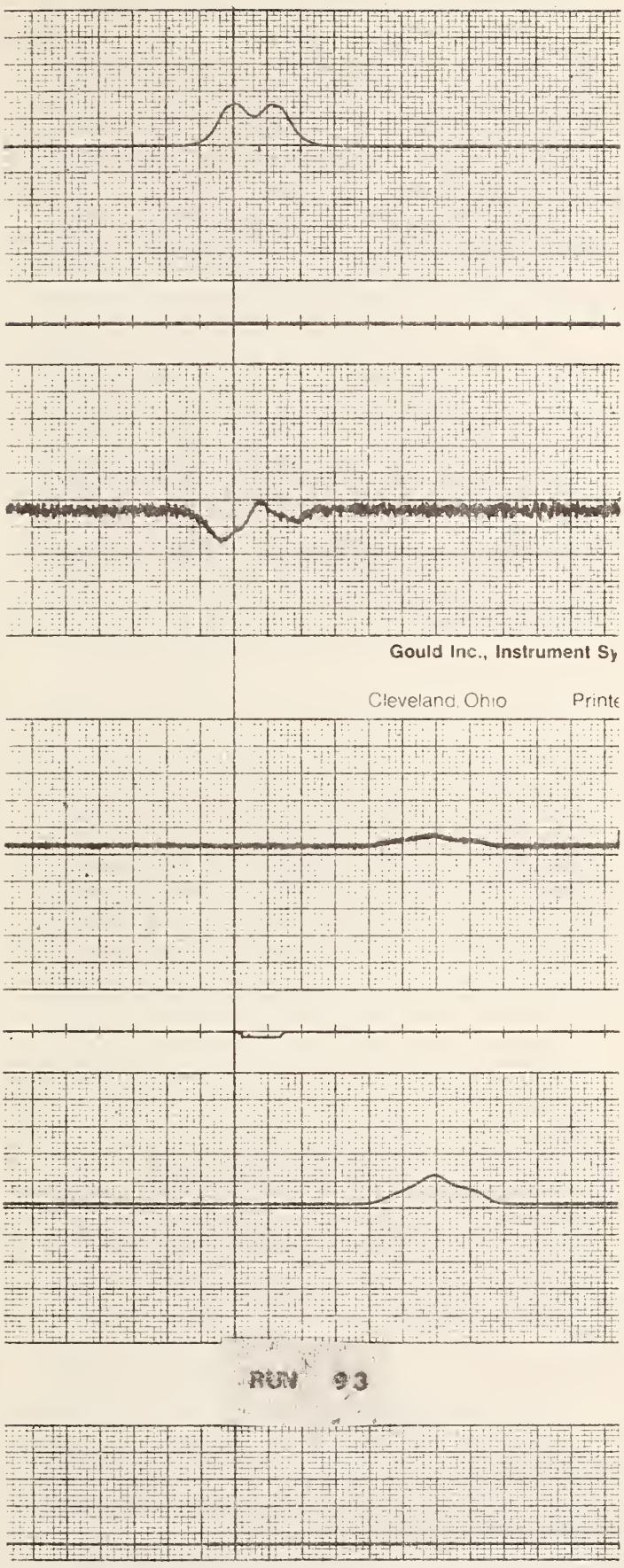
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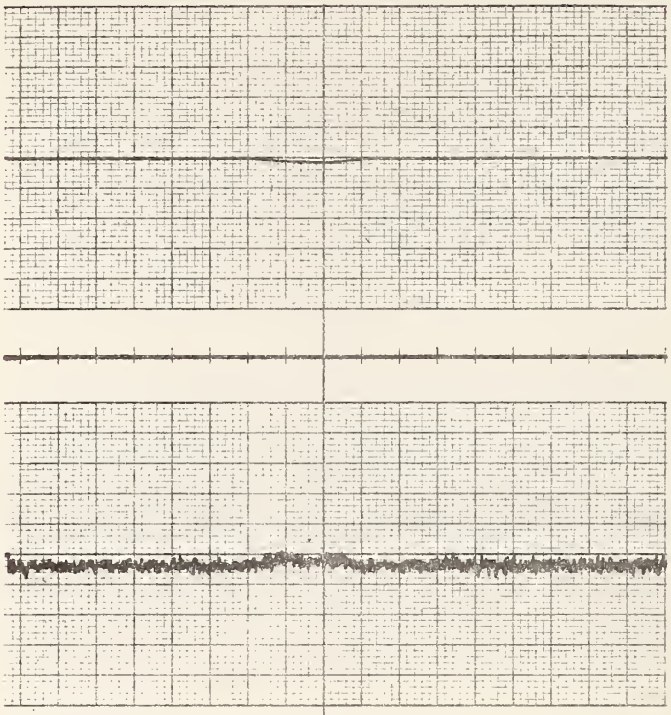
Cleveland, Ohio
Printe
RUN 93



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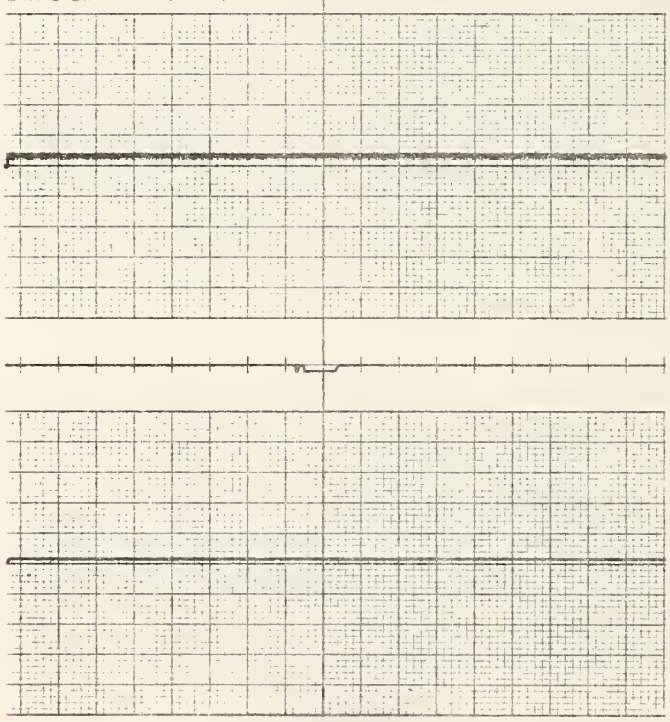

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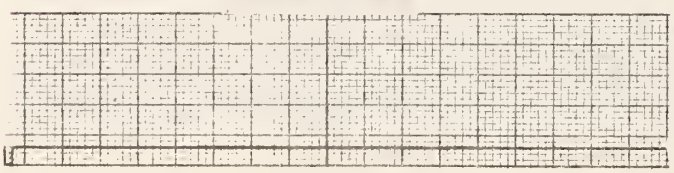
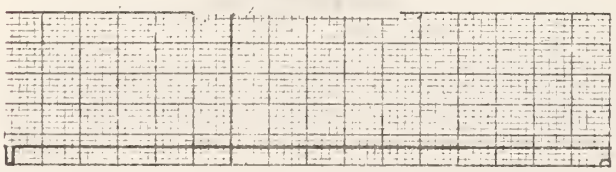
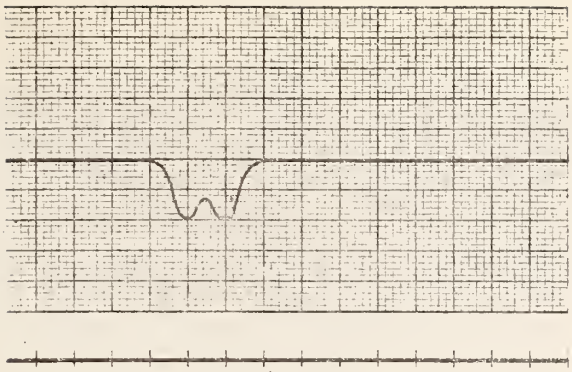
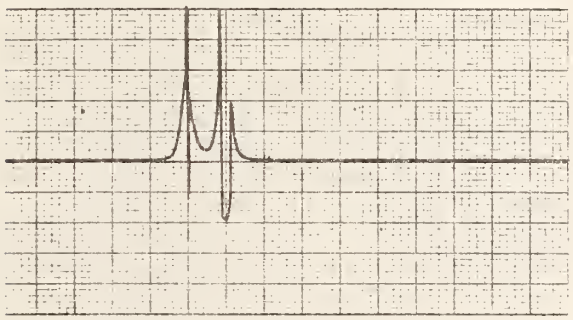


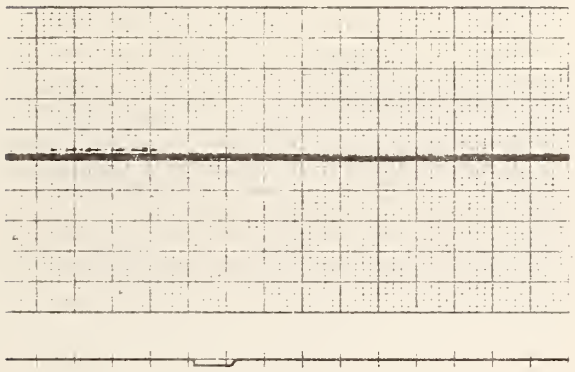
ALN 95

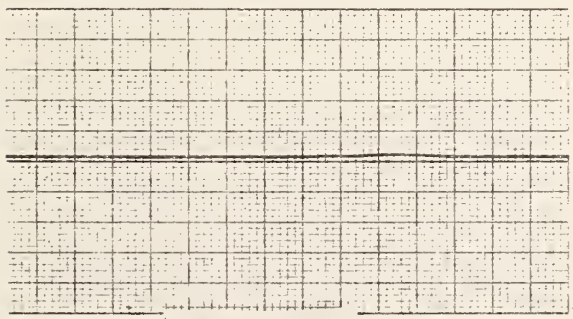
RUN 96



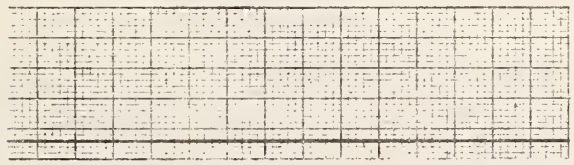


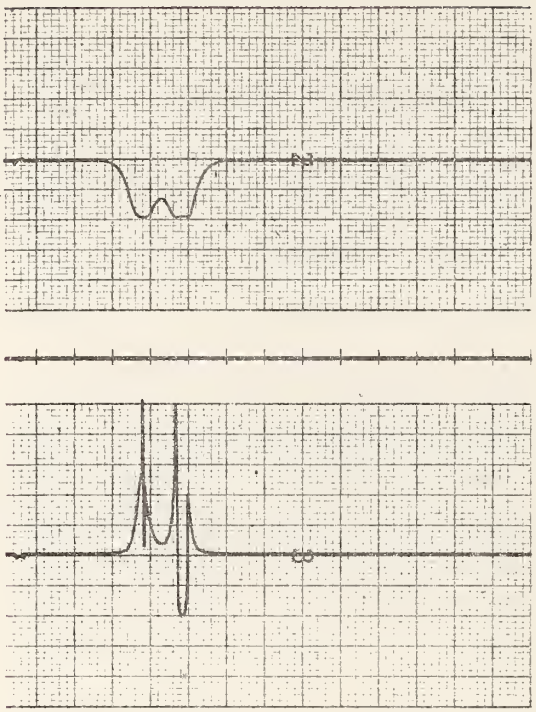




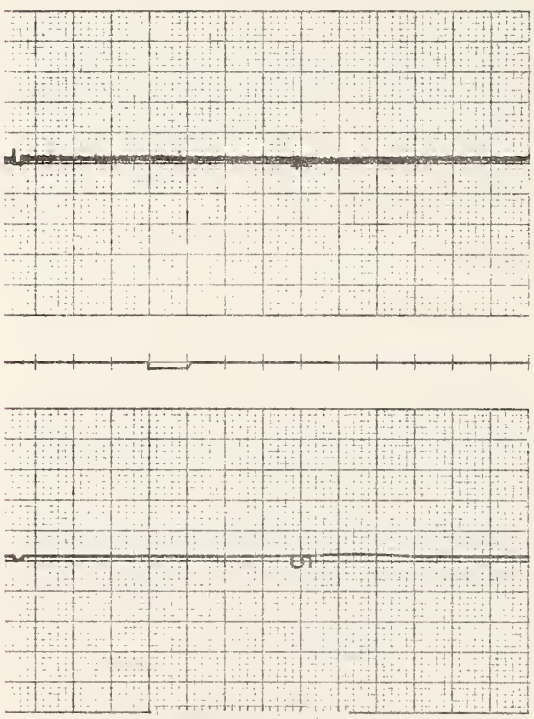


RUN 97

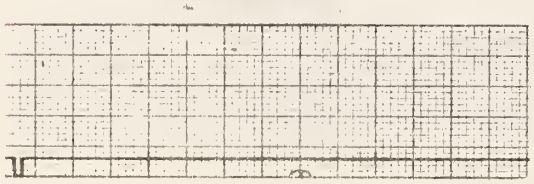


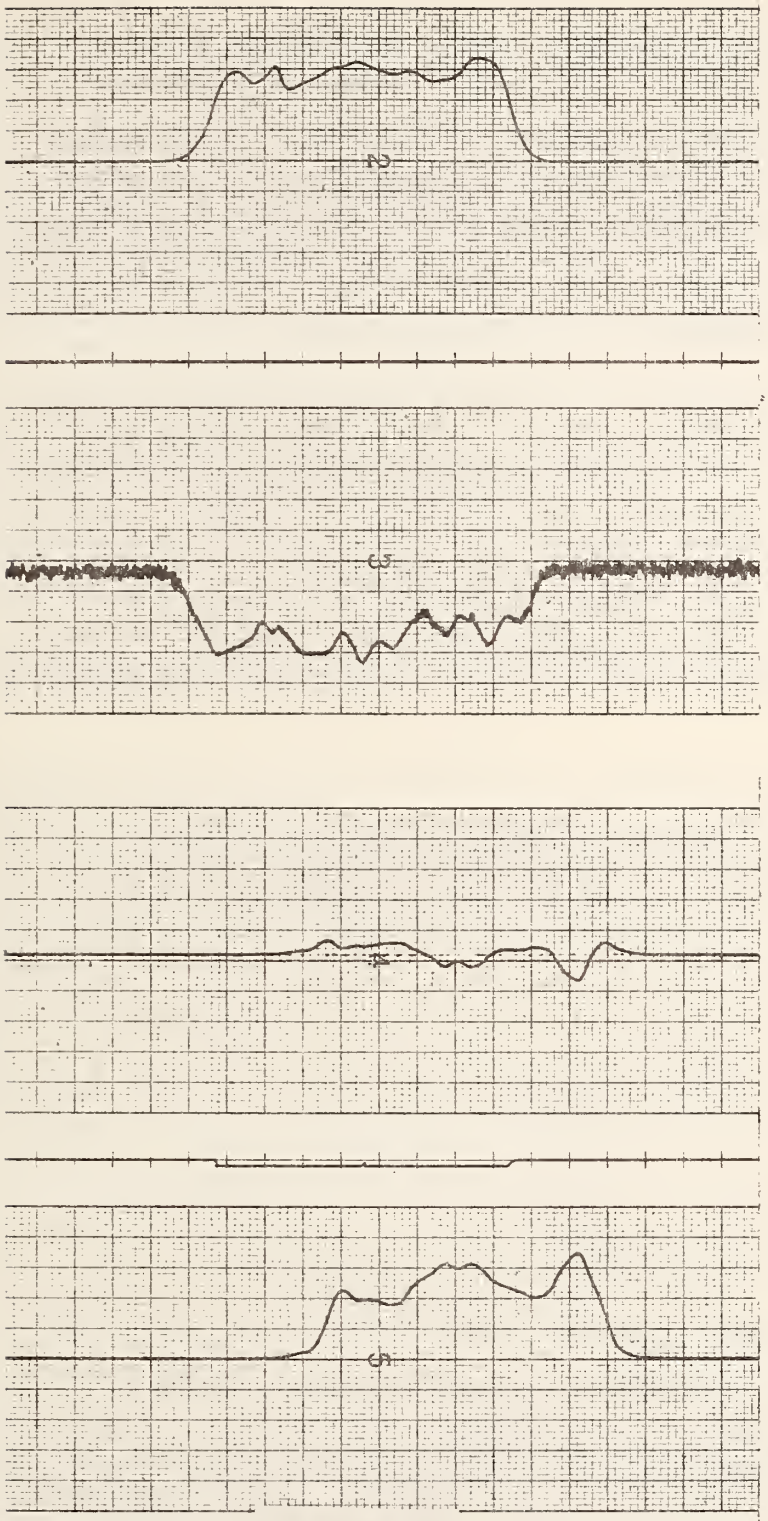


BRUSH ACCUCHART

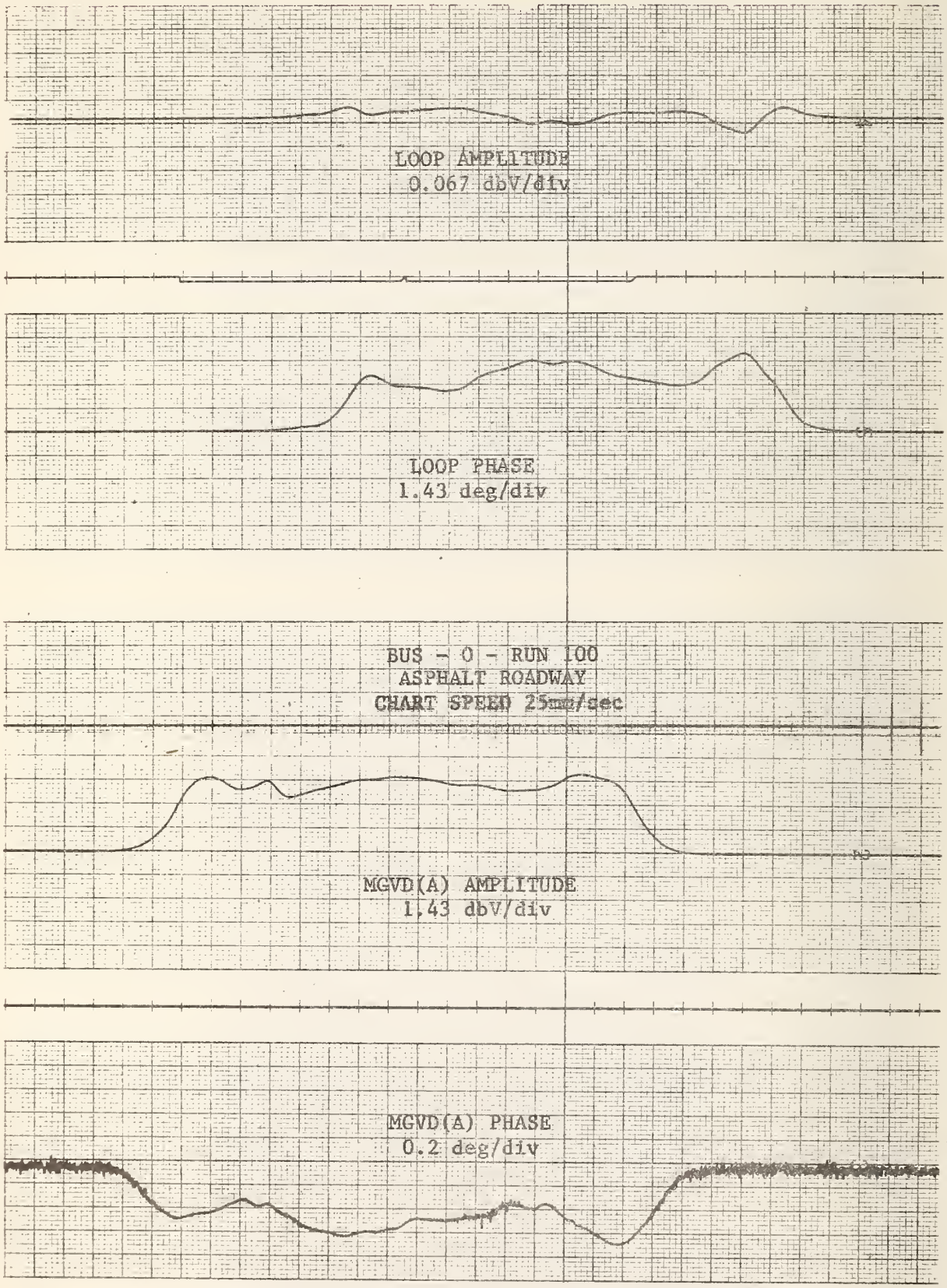


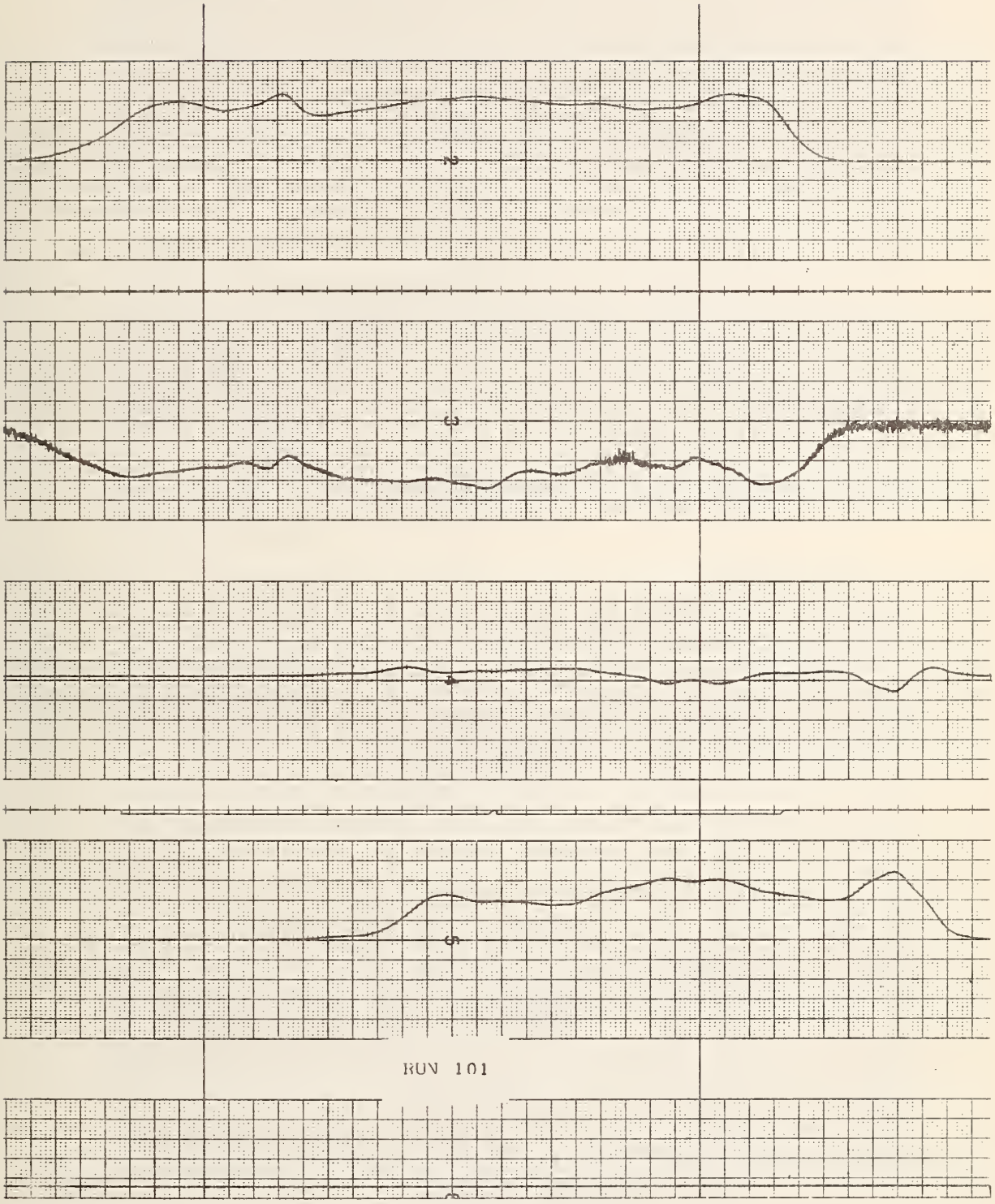
RUN 98



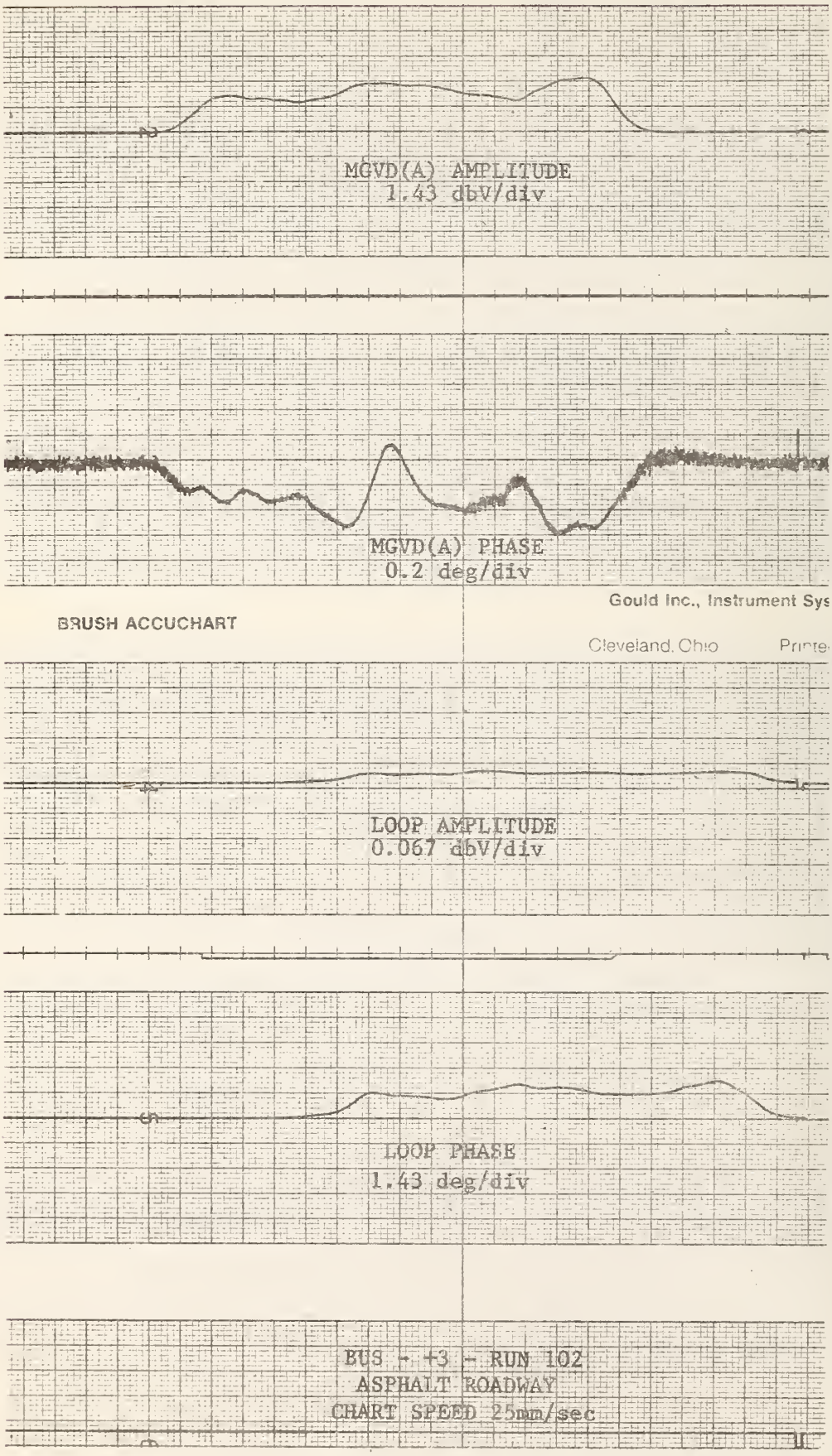


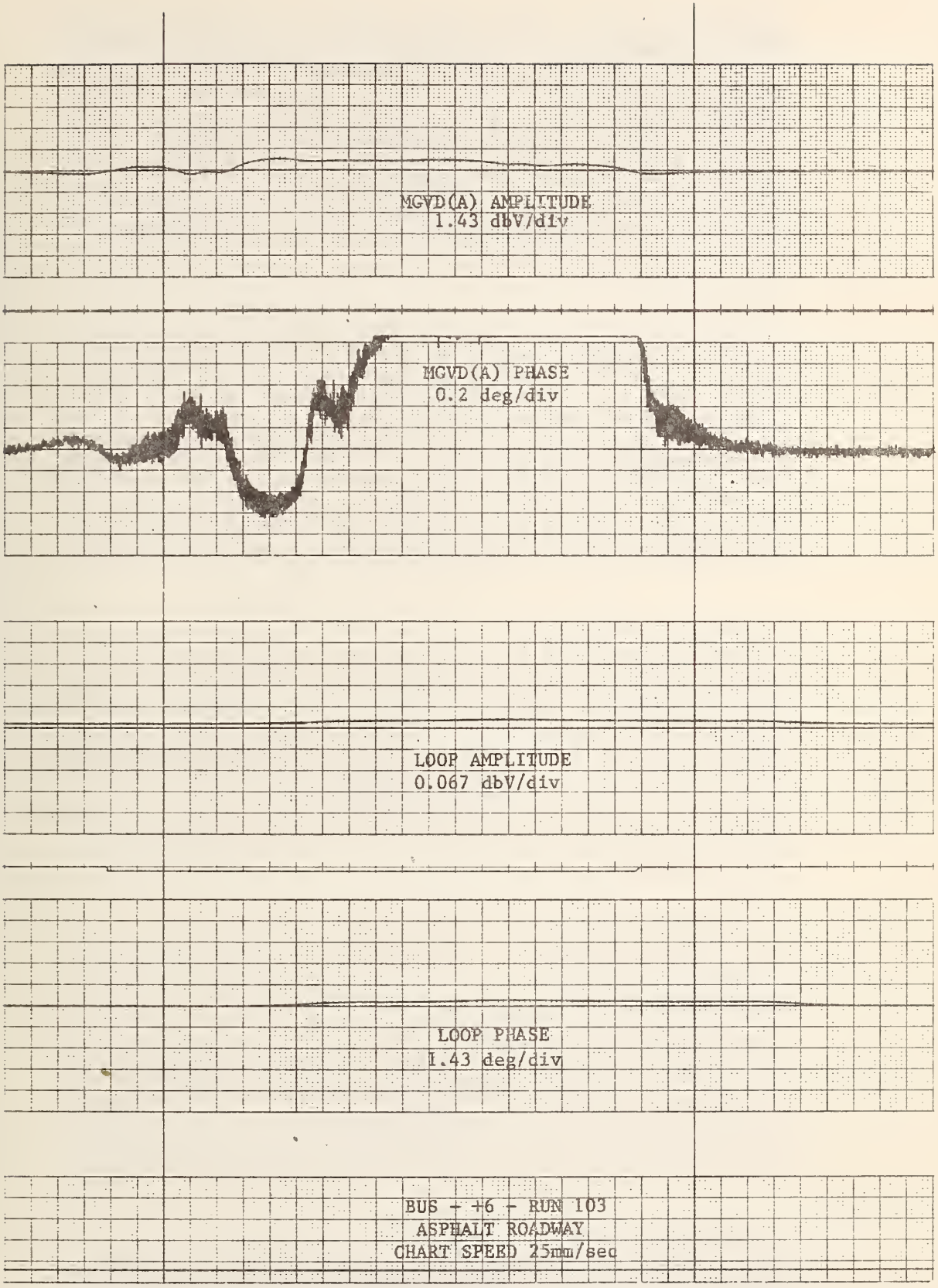
RUN 99

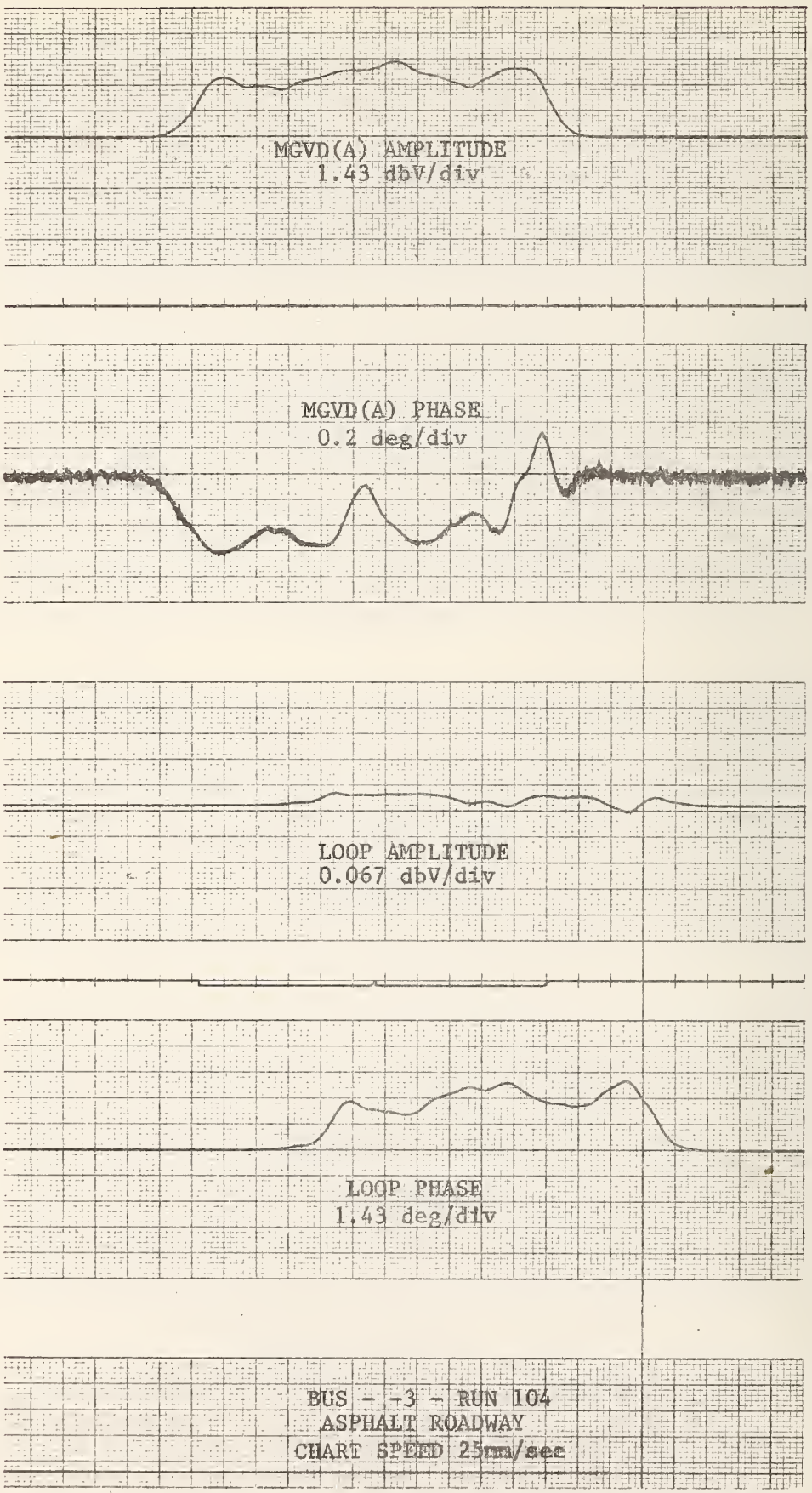

LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
BUS - 0 - RUN 100
ASPHALT ROADWAY
CHART SPEED 25mm/sec
MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div

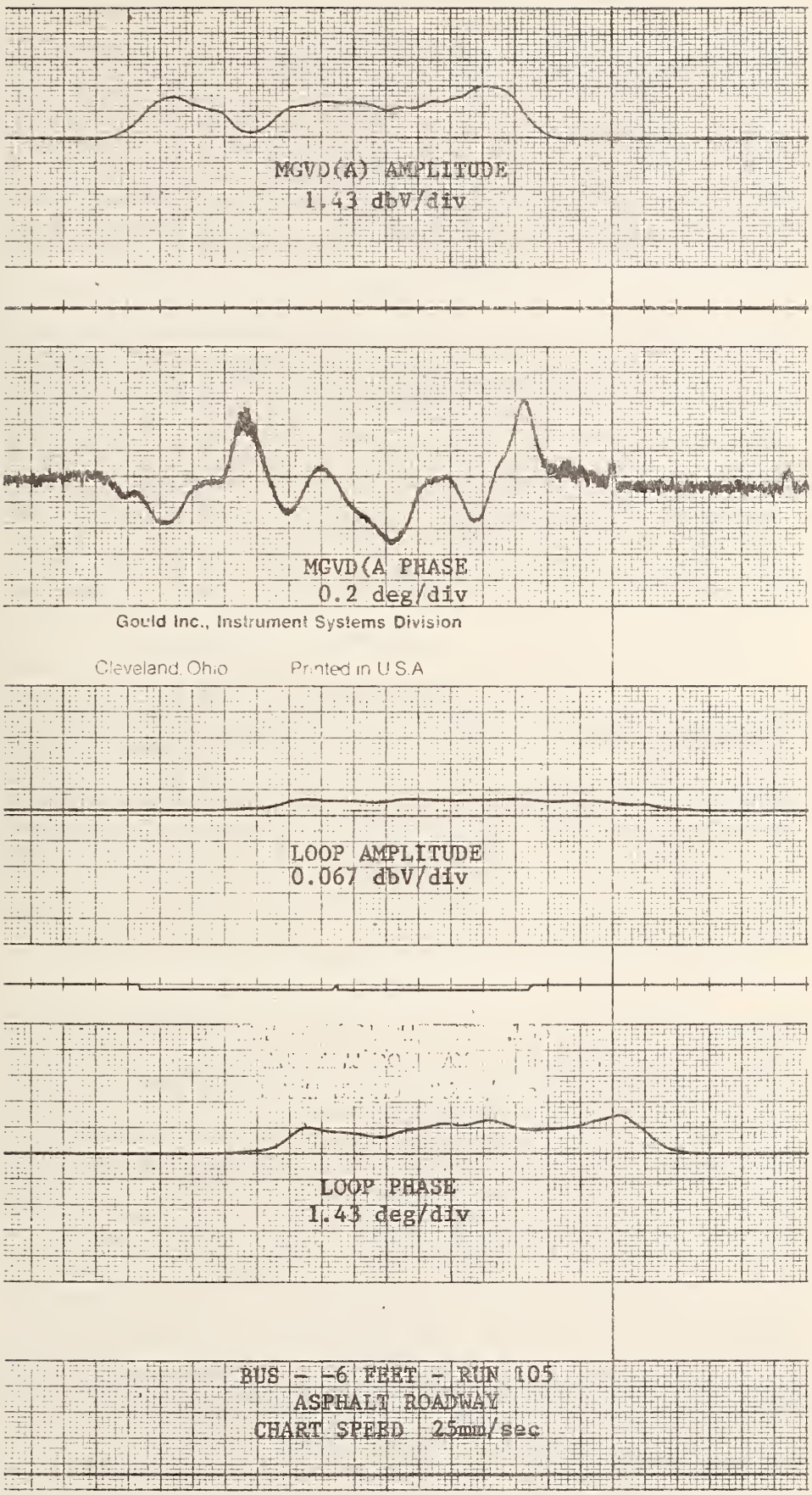


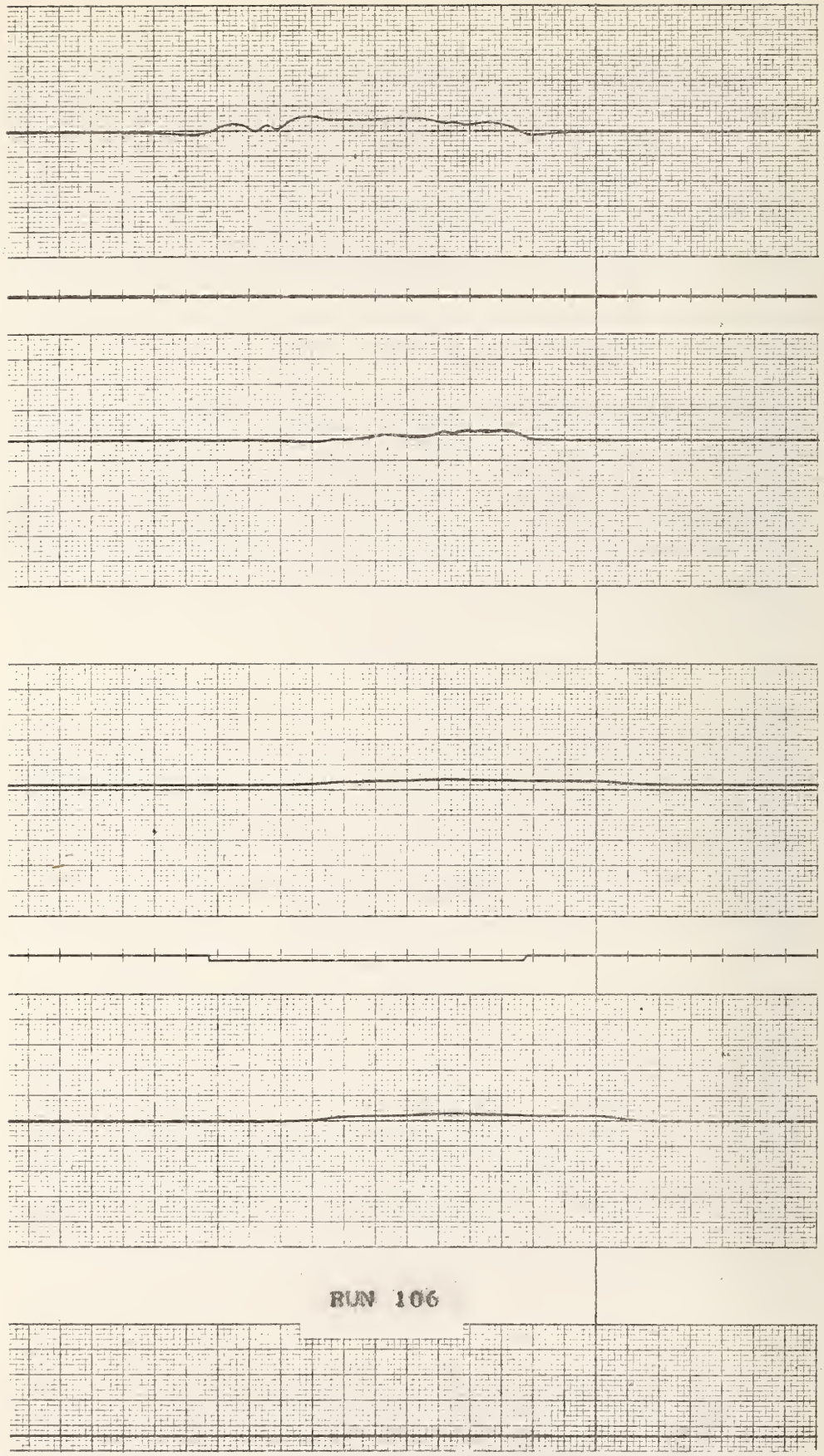
RUN 101

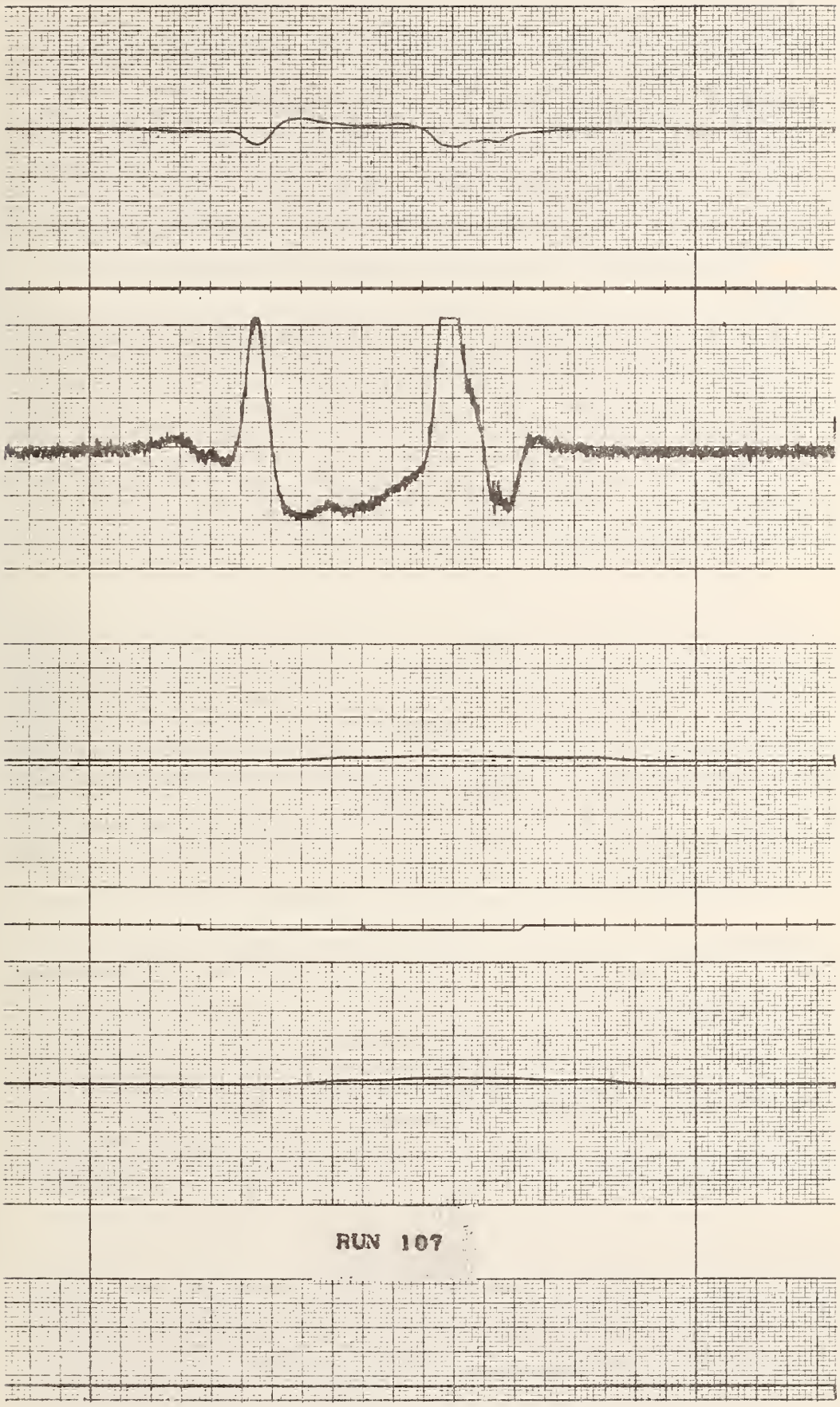

MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
Gould Inc., Instrument Sys
BRUSH ACCUCHART
Cleveland, Ohio
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
BUS - +3 - RUN 102
ASPHALT ROADWAY
CHART SPEED 25mm/sec

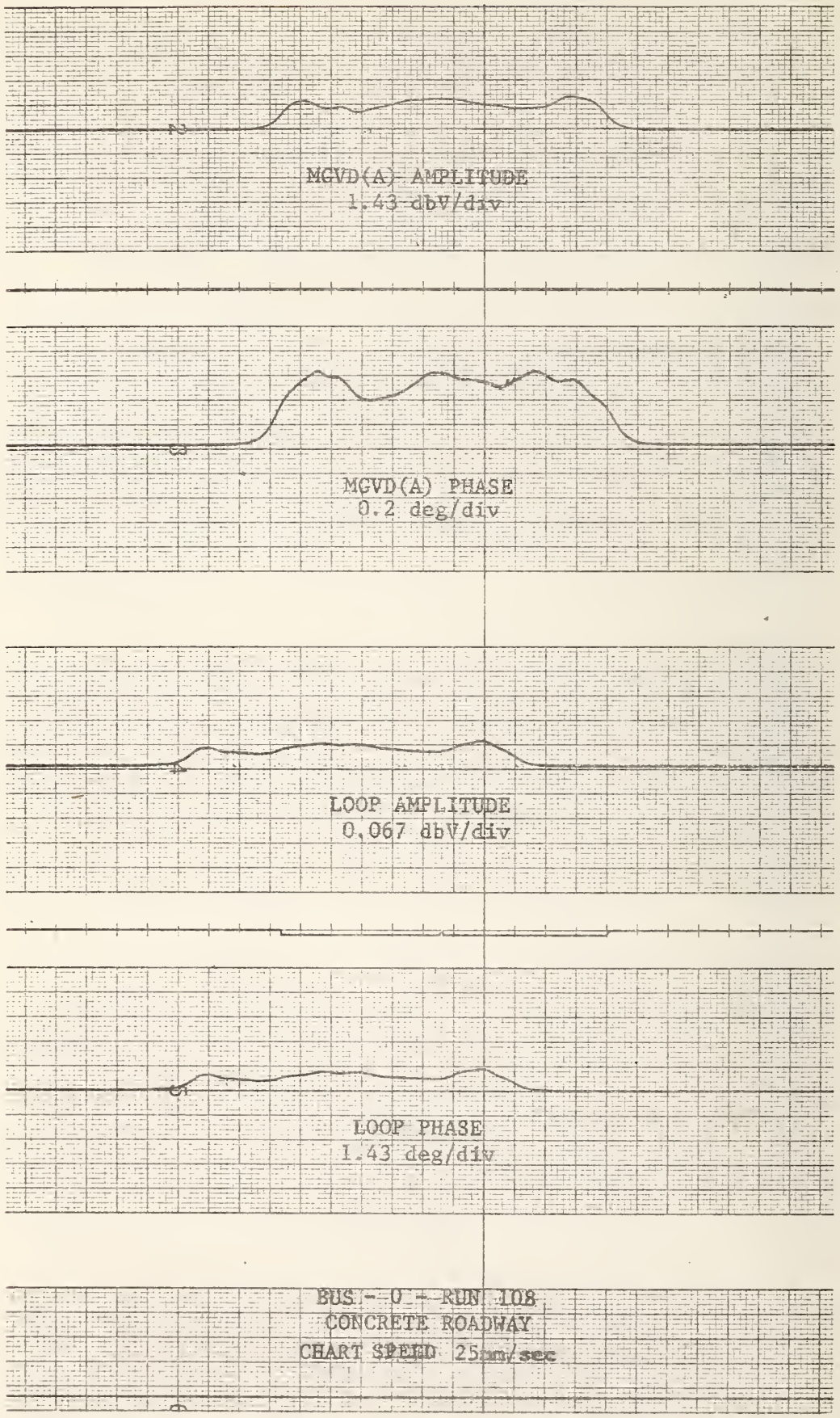

MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
BUS - +6 - RUN 103
ASPHALT ROADWAY
CHART SPEED 25mm/sec

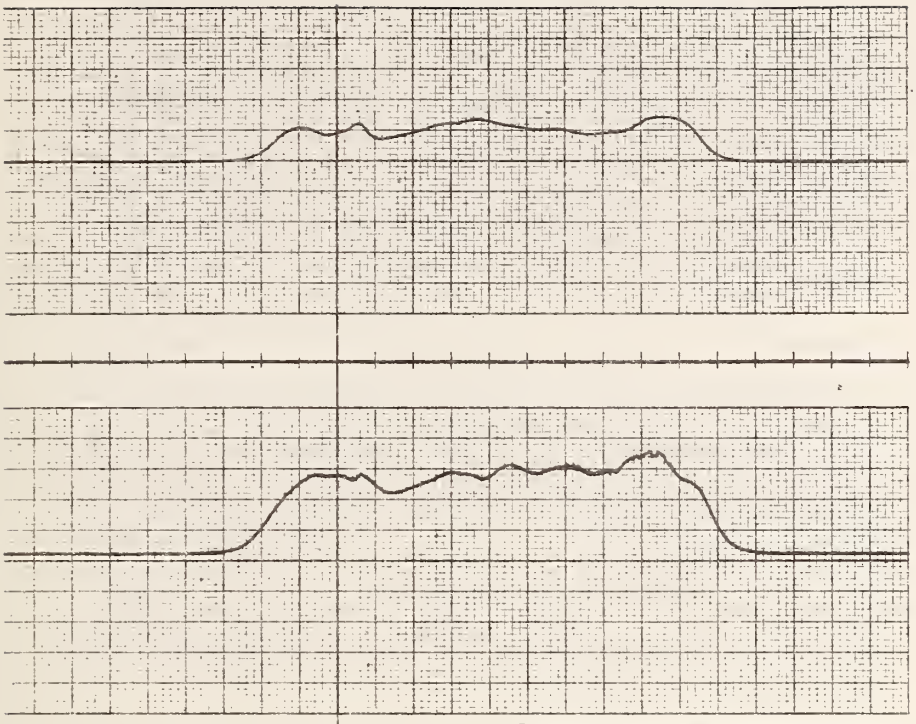

MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
BUS - -3 - RUN 104
ASPHALT ROADWAY
CHART SPEED 25mm/sec


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A PHASE
0.2 deg/div
Gould Inc., Instrument Systems Division
Cleveland, Ohio
Printed in U.S.A
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
BUS - -6 FEET - RUN 105
ASPHALT ROADWAY
CHART SPEED 25mm/sec


RUN 106


RUN 107


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
BUS - 0 - RUN 108
CONCRETE ROADWAY
CHART SPEED 25mm/sec



Gould Inc., Instrument Systems Divisio

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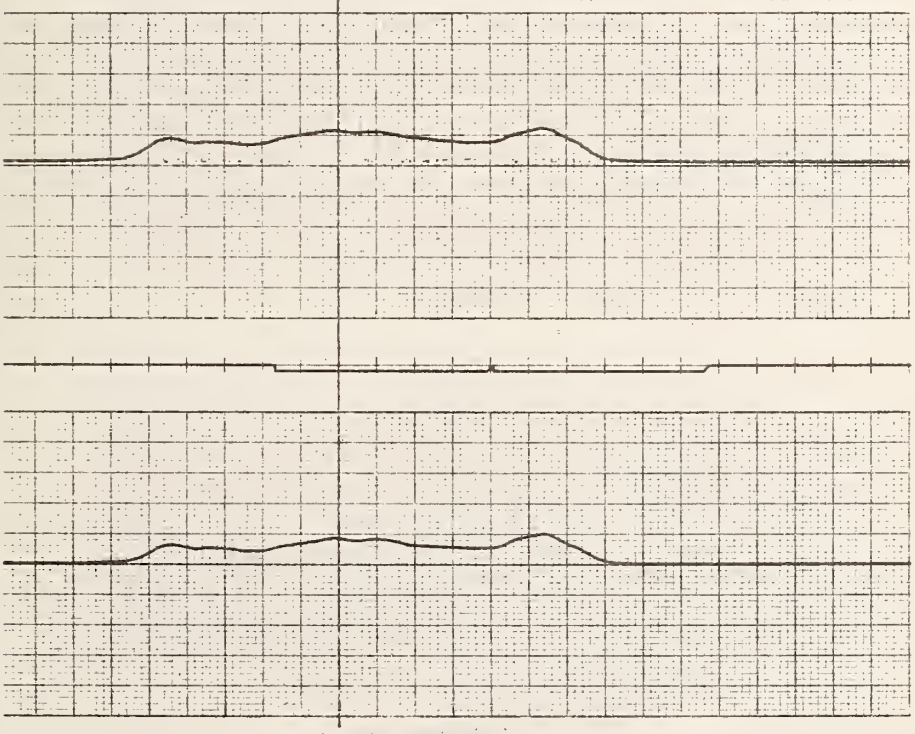
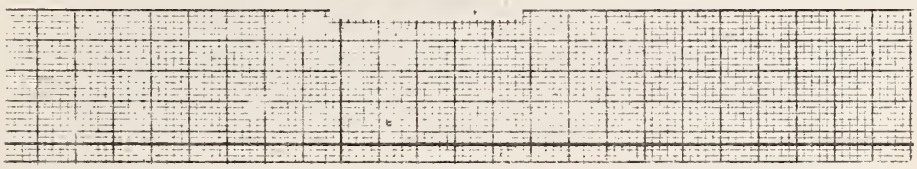
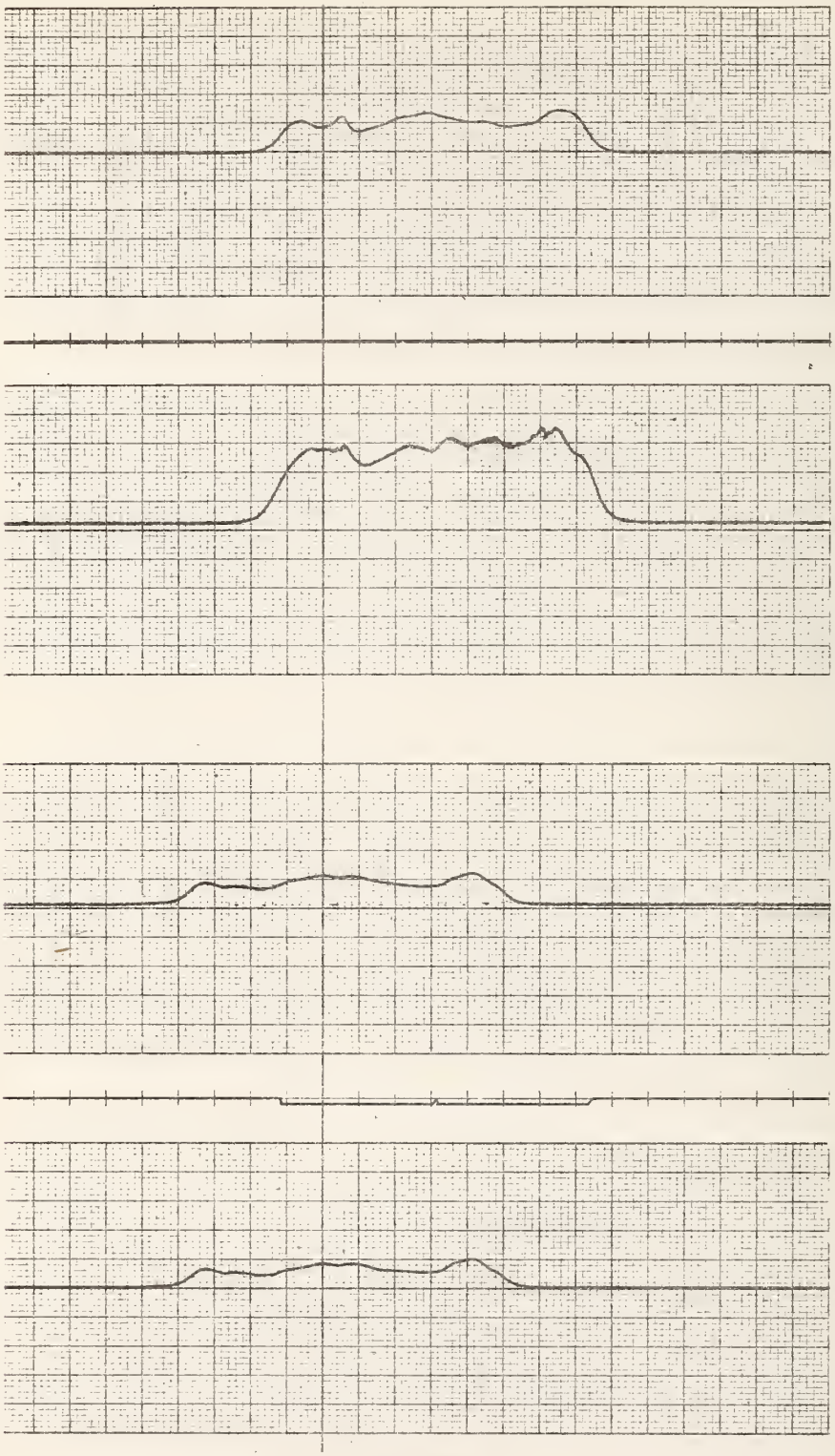
Cleveland, Ohio Printed in U.S.A

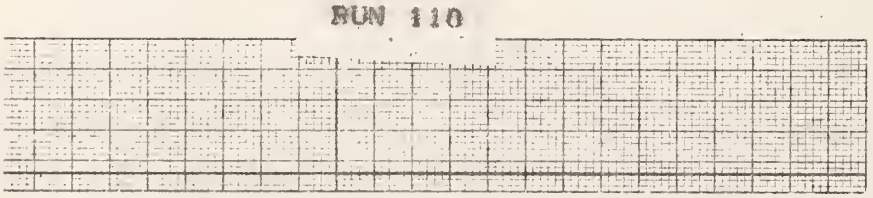


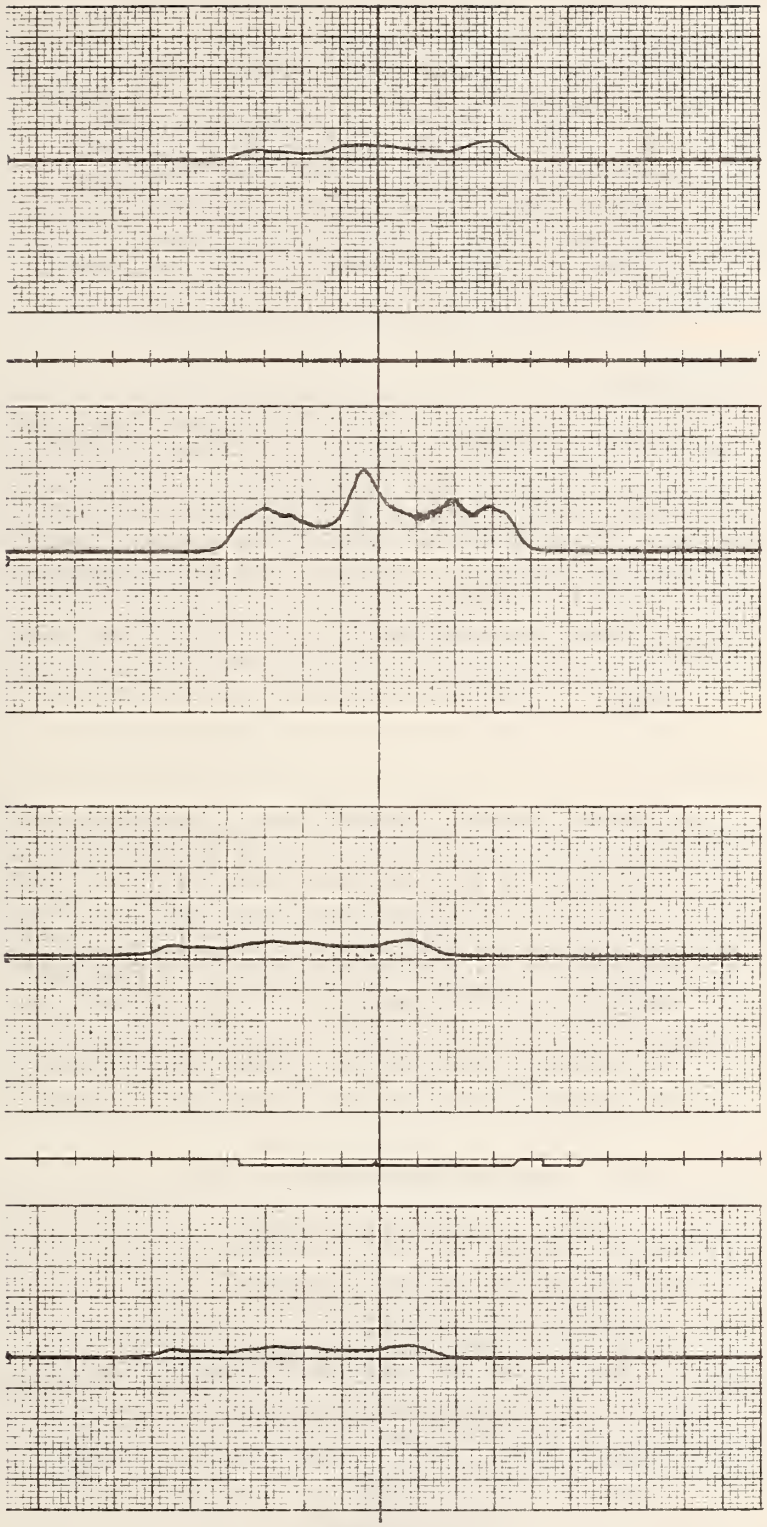
RUN 109



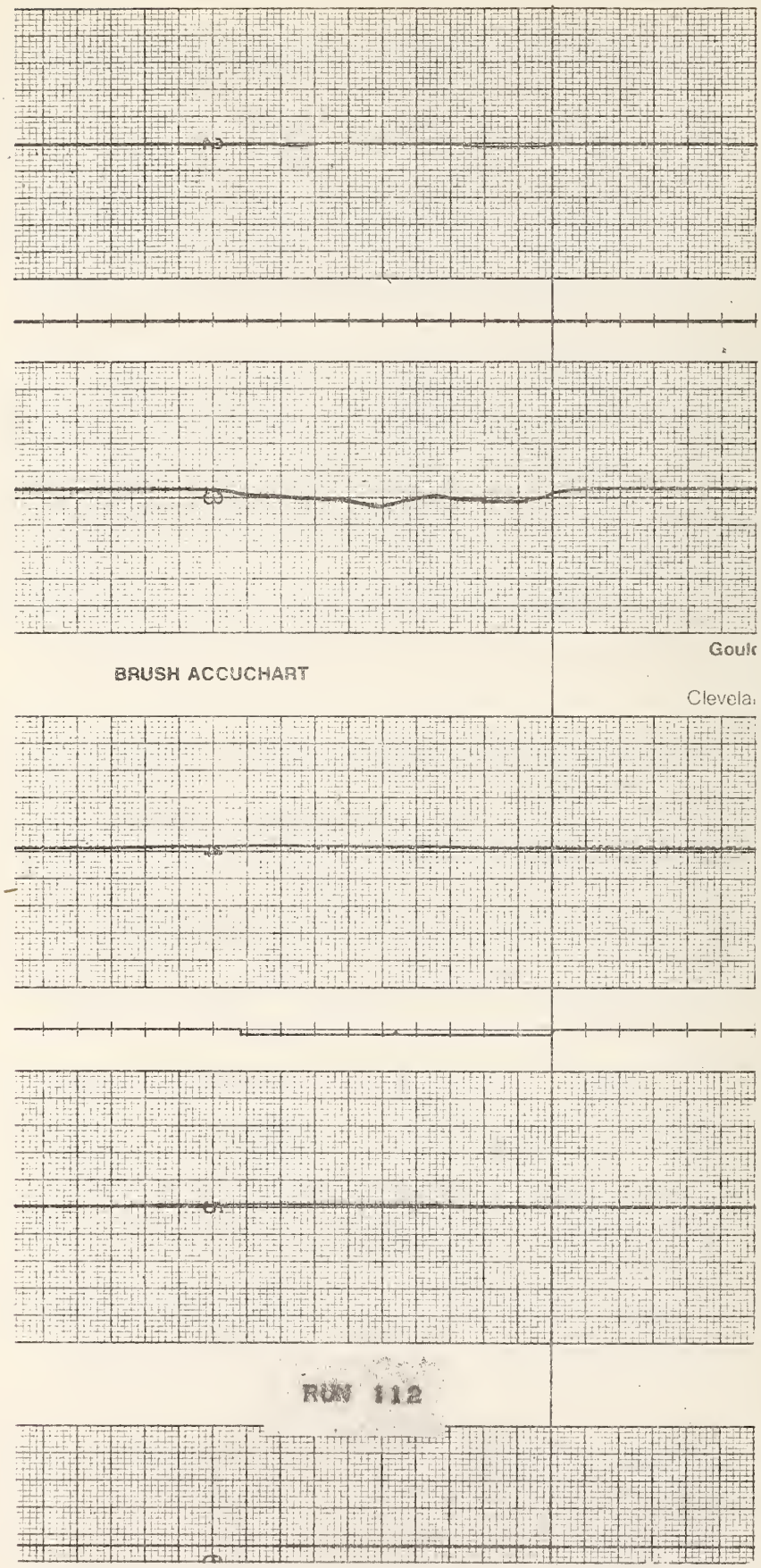


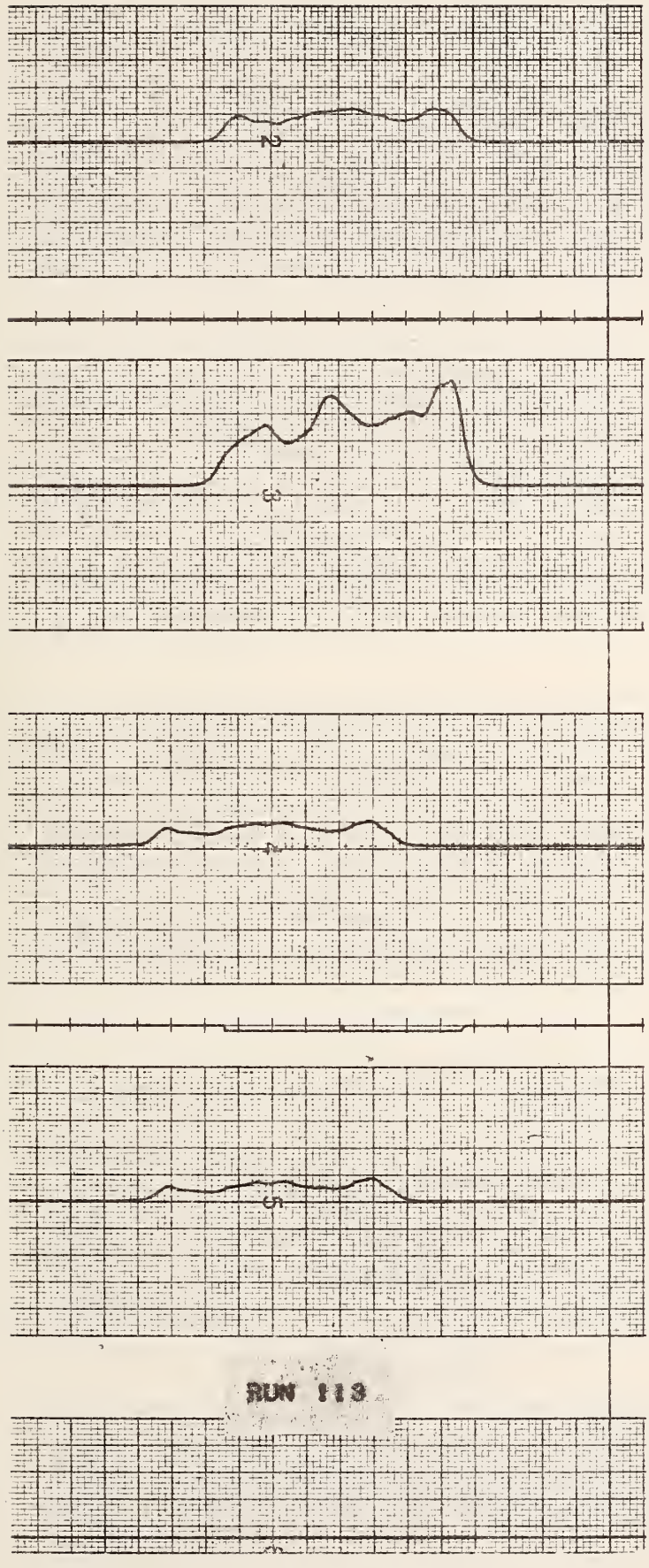
RUN 110

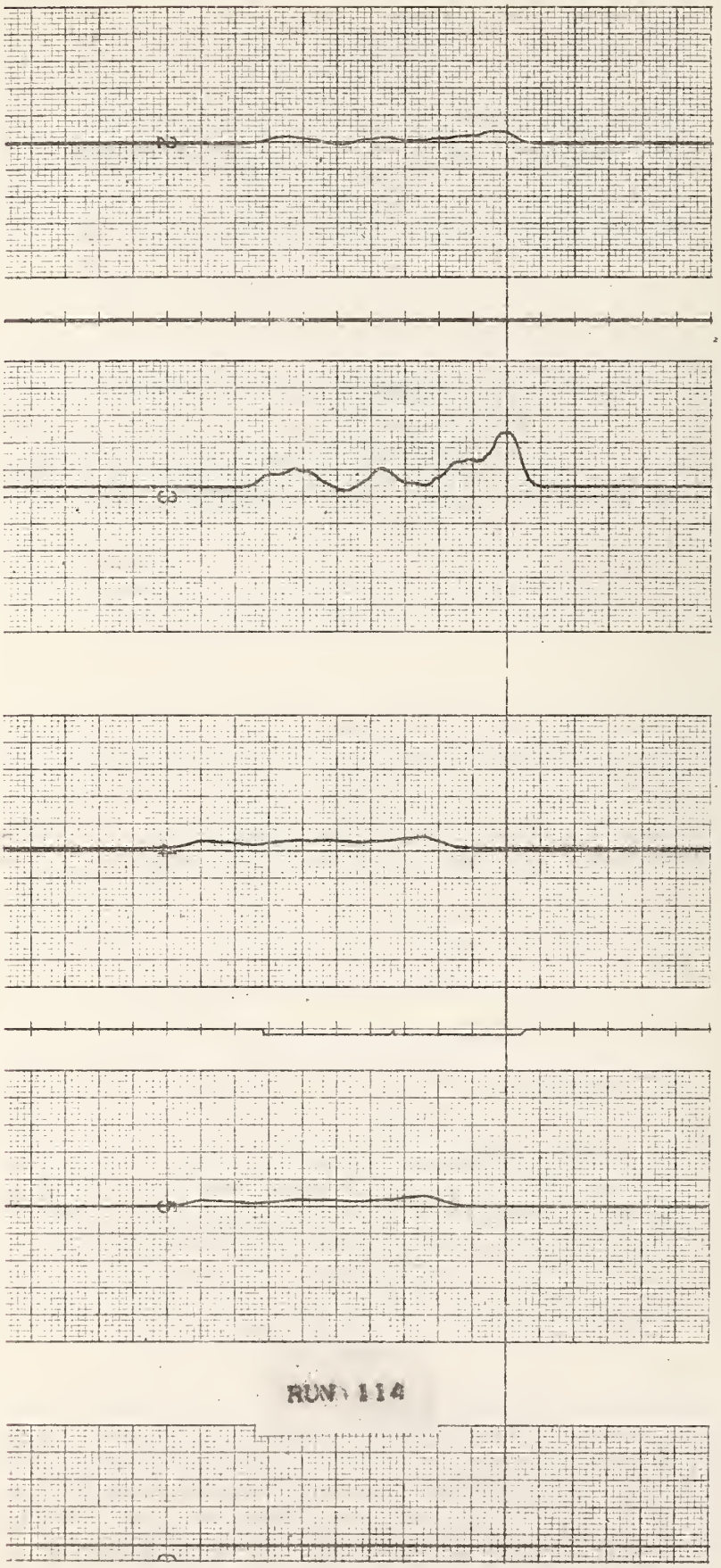


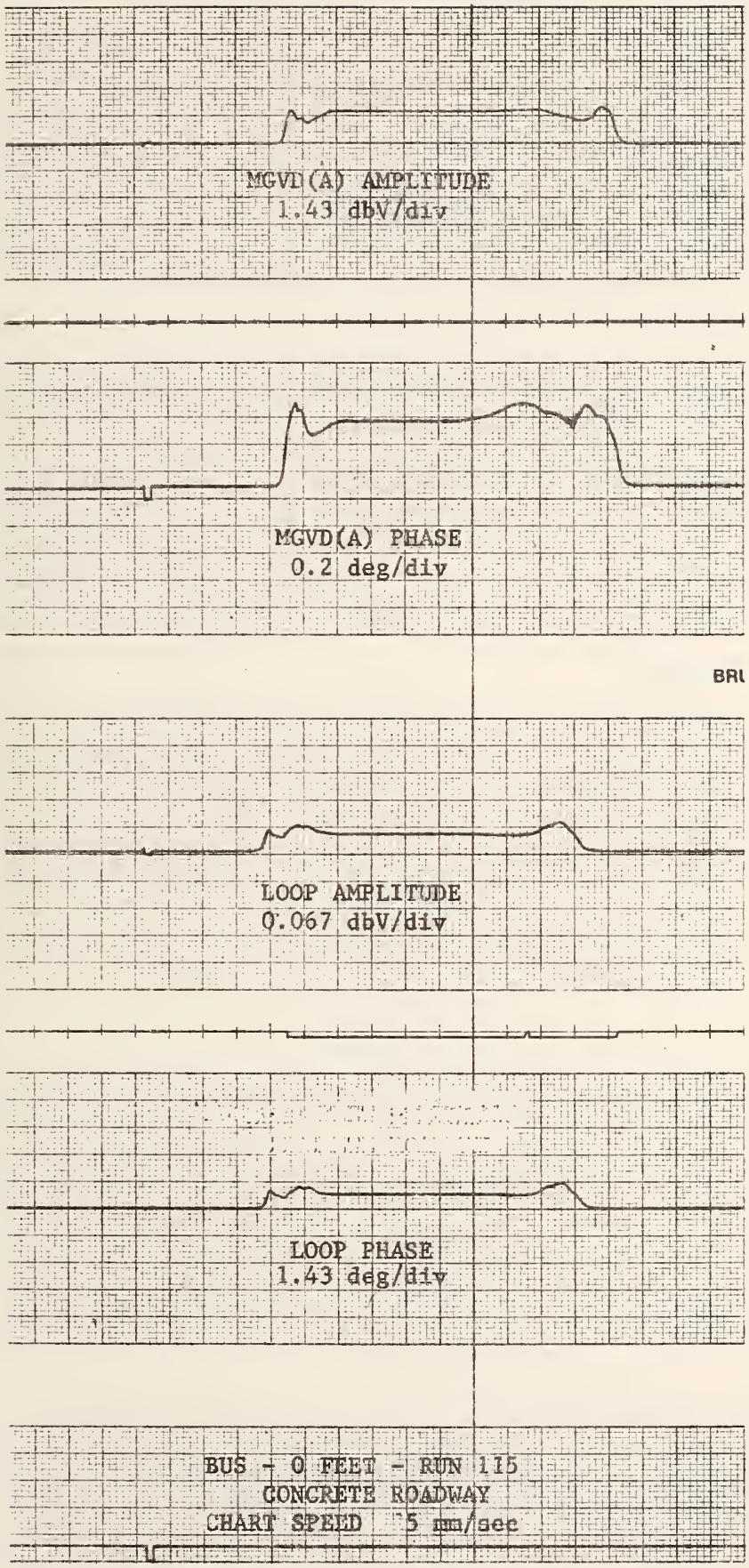


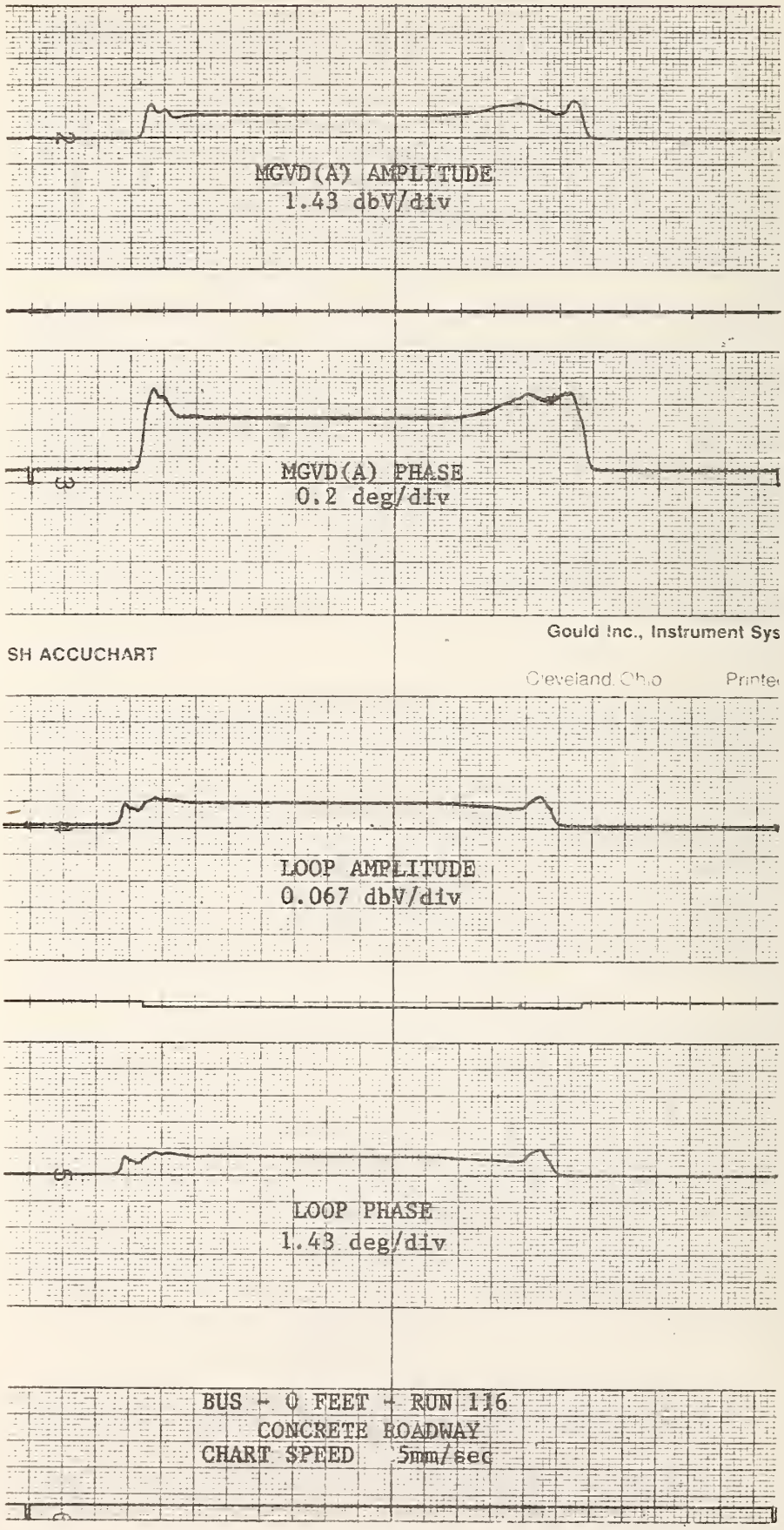
RUN 111


Gould
BRUSH ACCUCHART
Clevela
RUN 112


RUN 113

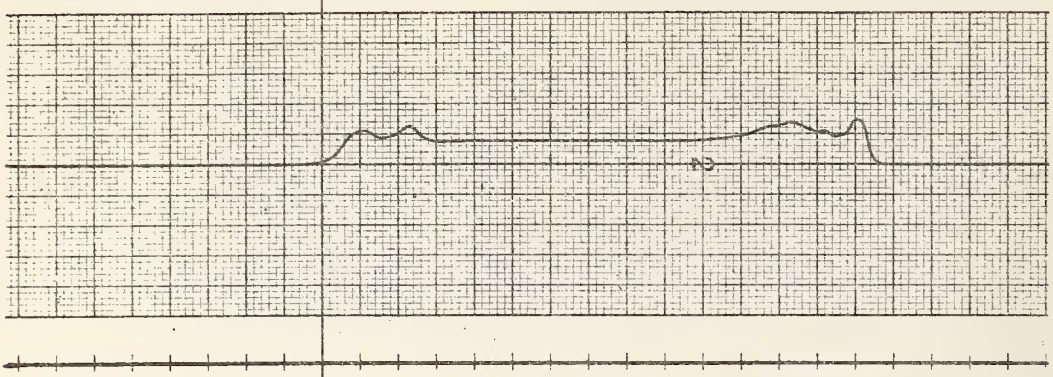

RUN 114

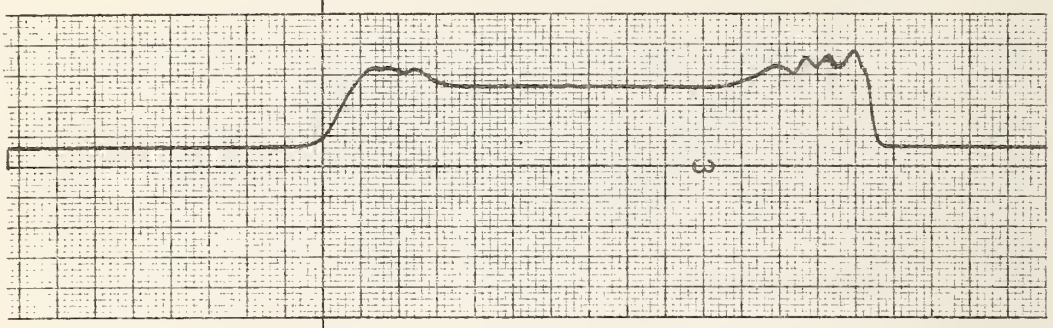

MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
BUS - 0 FEET - RUN 115
CONCRETE ROADWAY
CHART SPEED 5 mm/sec


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
Gould Inc., Instrument Sys
SH ACCUCHART
Cleveland, Ohio
Printe
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
BUS - 0 FEET - RUN 116
CONCRETE ROADWAY
CHART SPEED 5mm/sec

Run 117

No Strip Recording
Available





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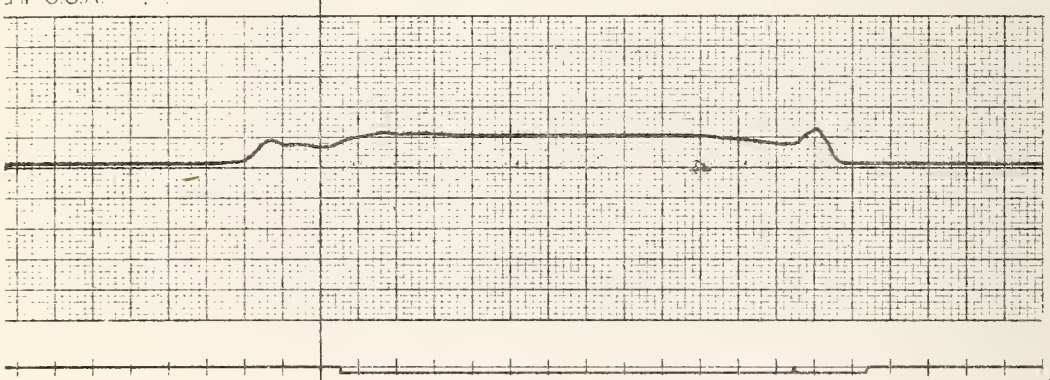
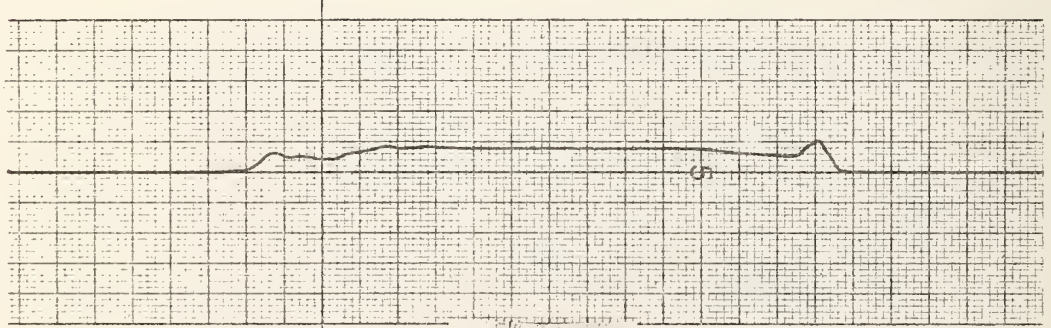
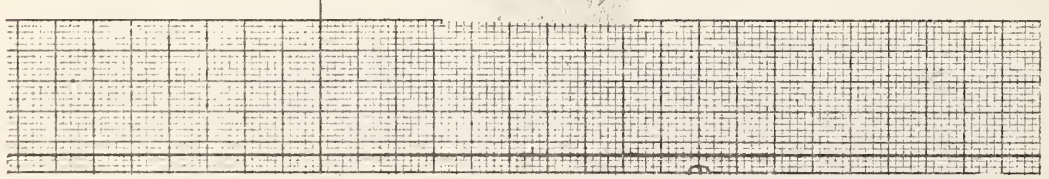
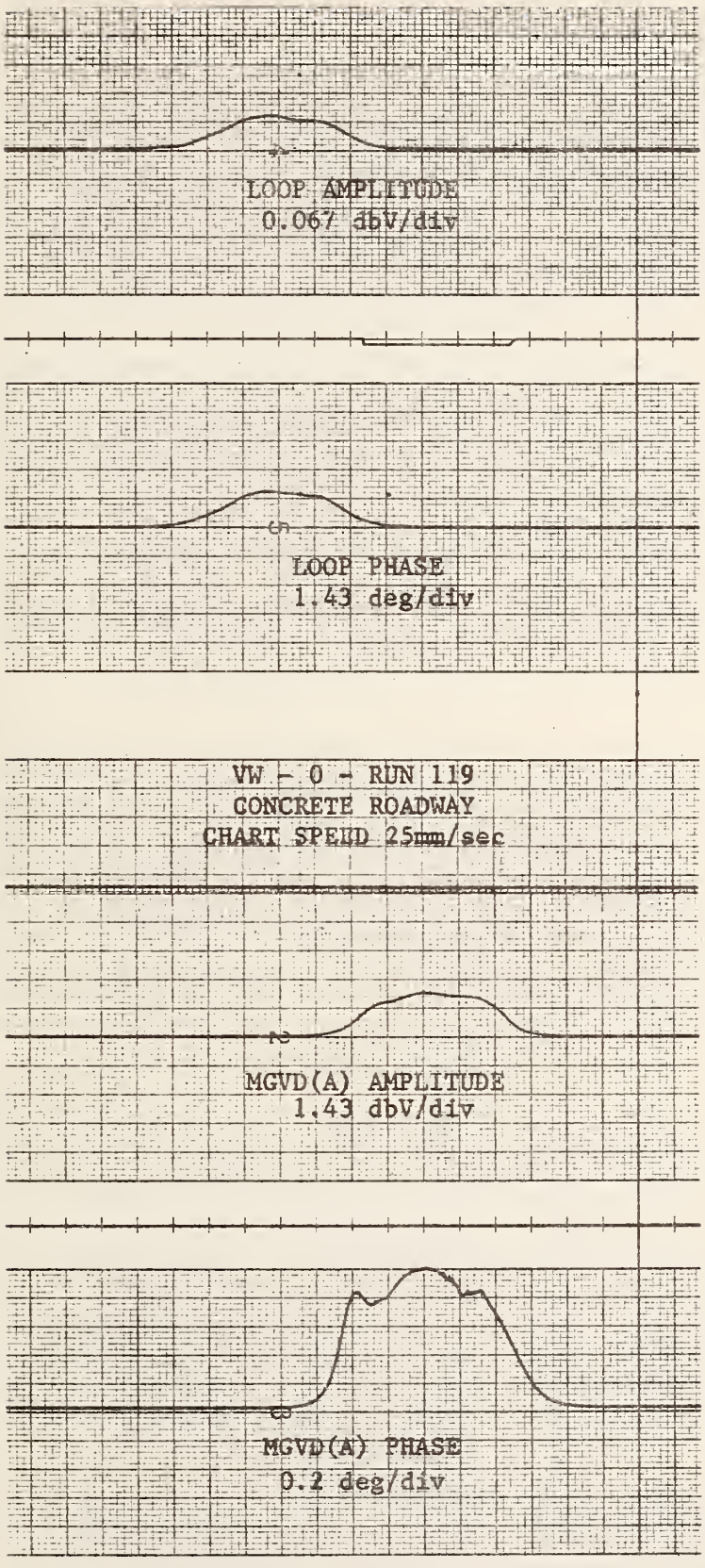


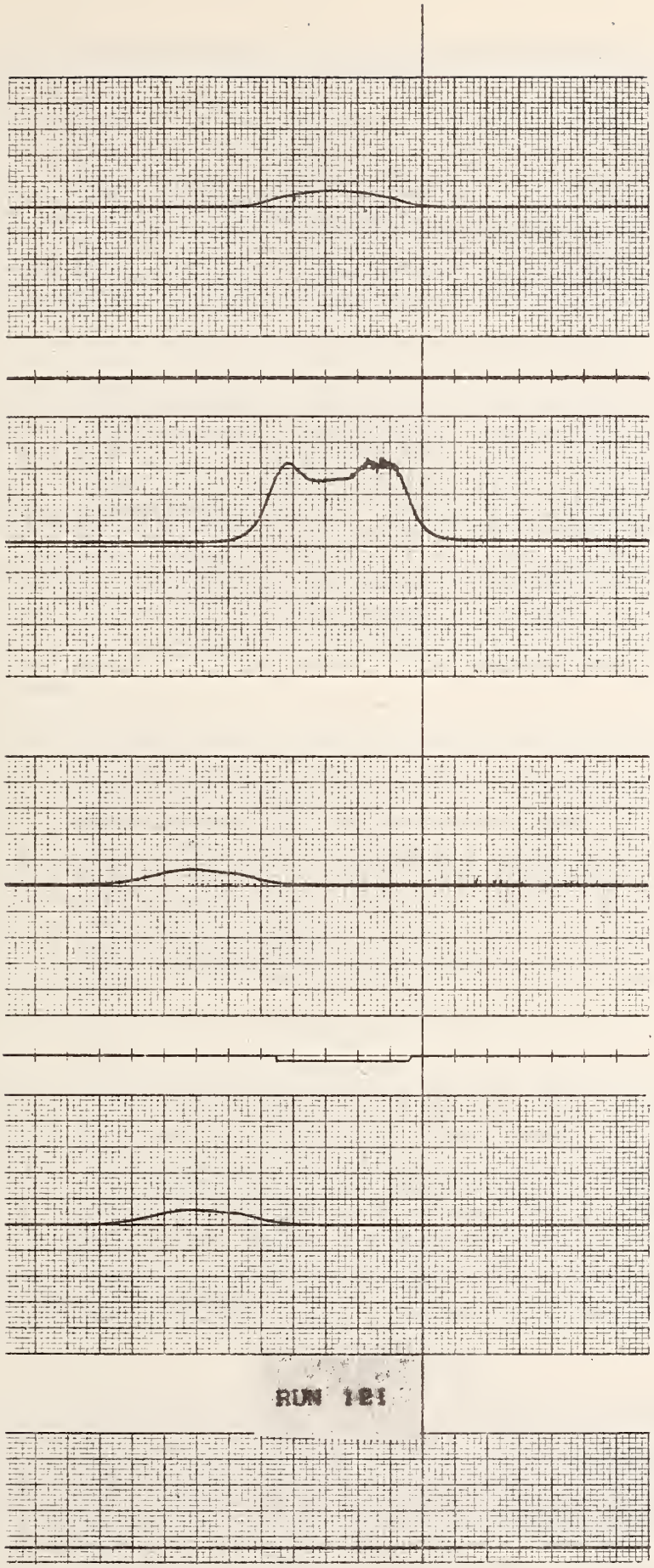


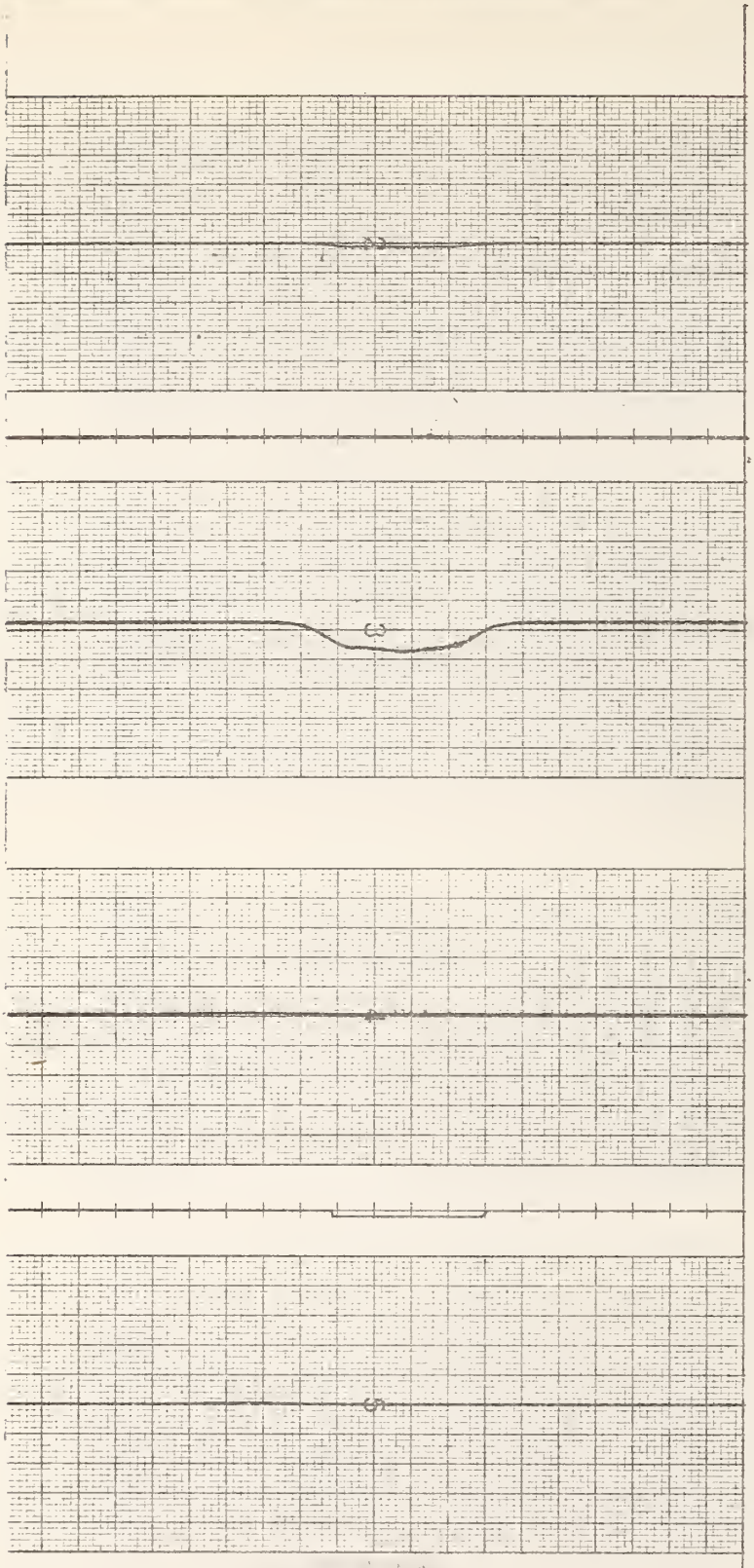
RUN 118



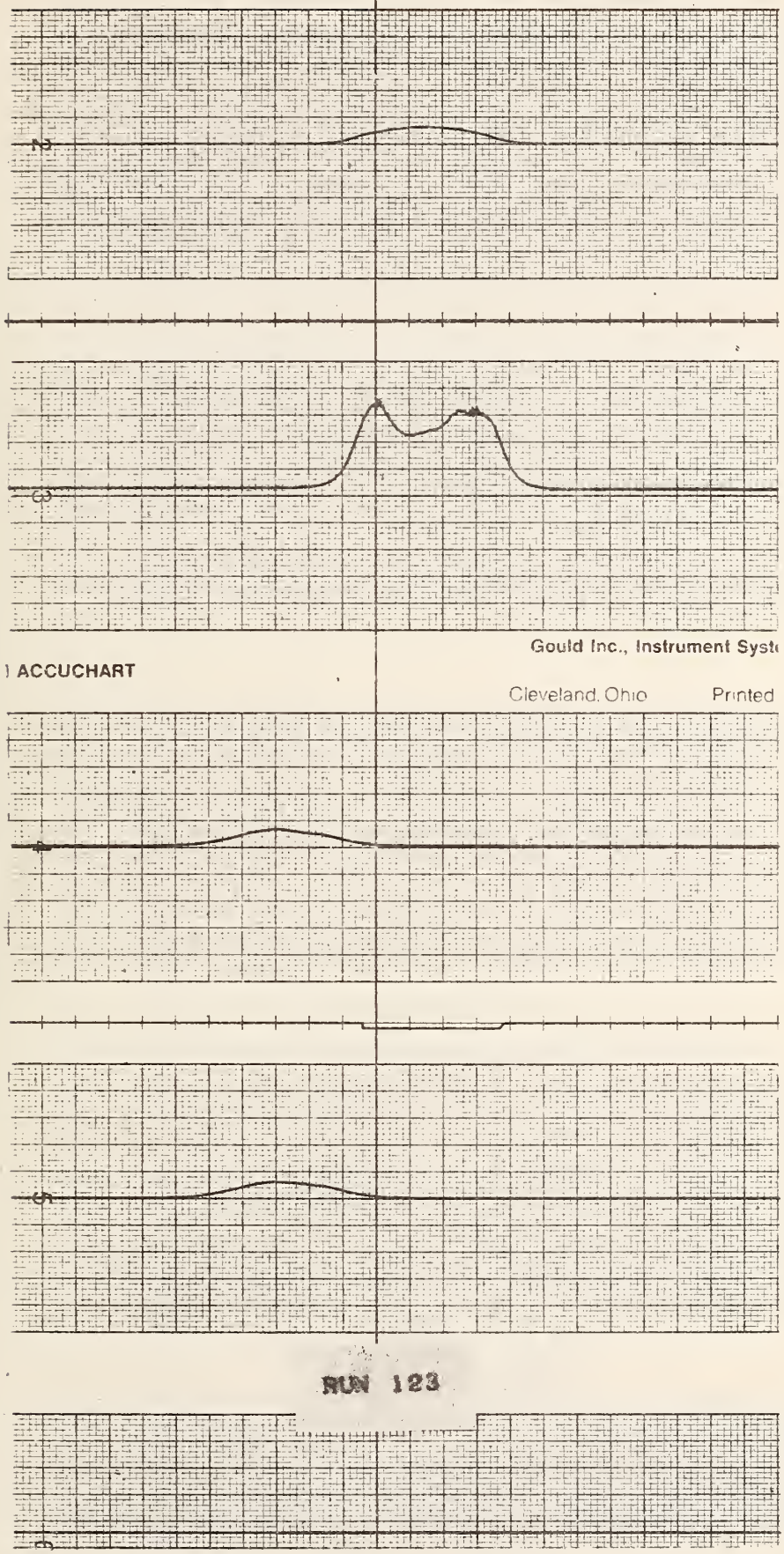

LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
VW - 0 - RUN 119
CONCRETE ROADWAY
CHART SPEED 25mm/sec
MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div

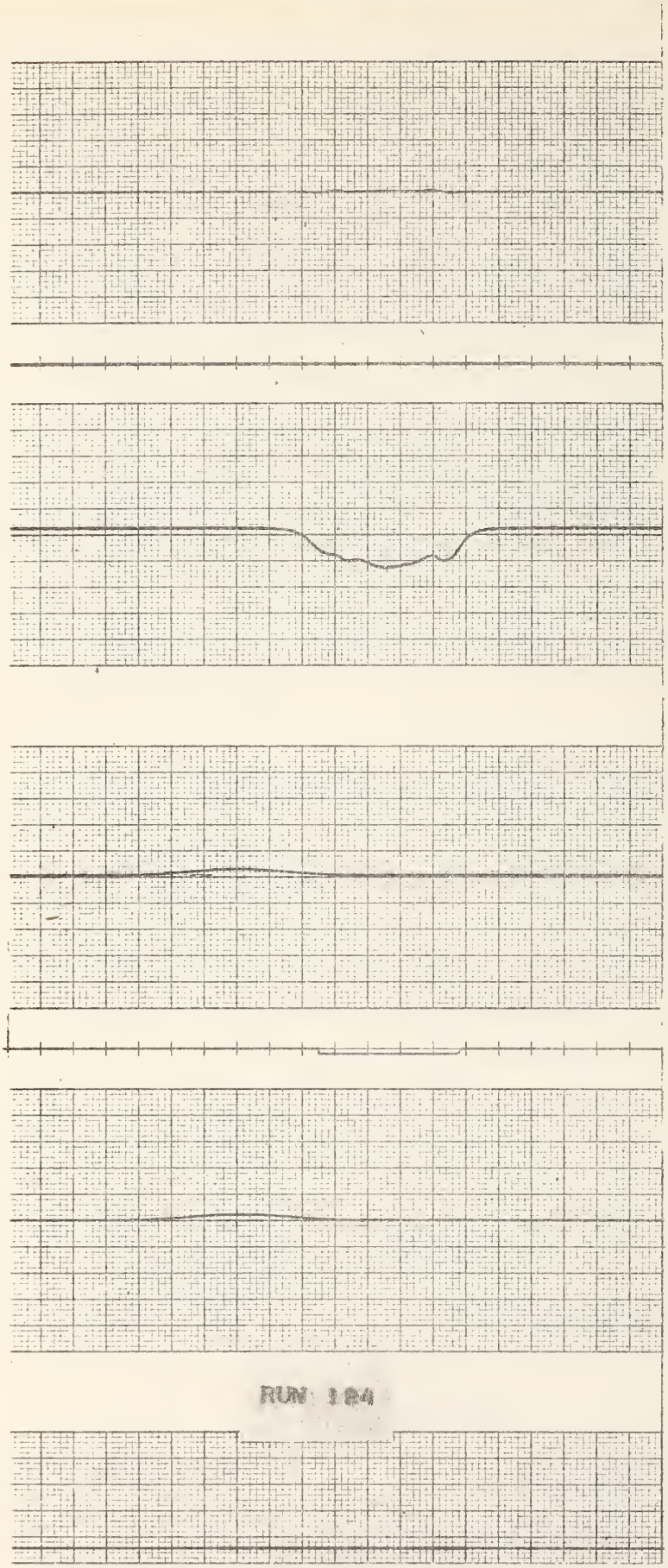
RUN 120

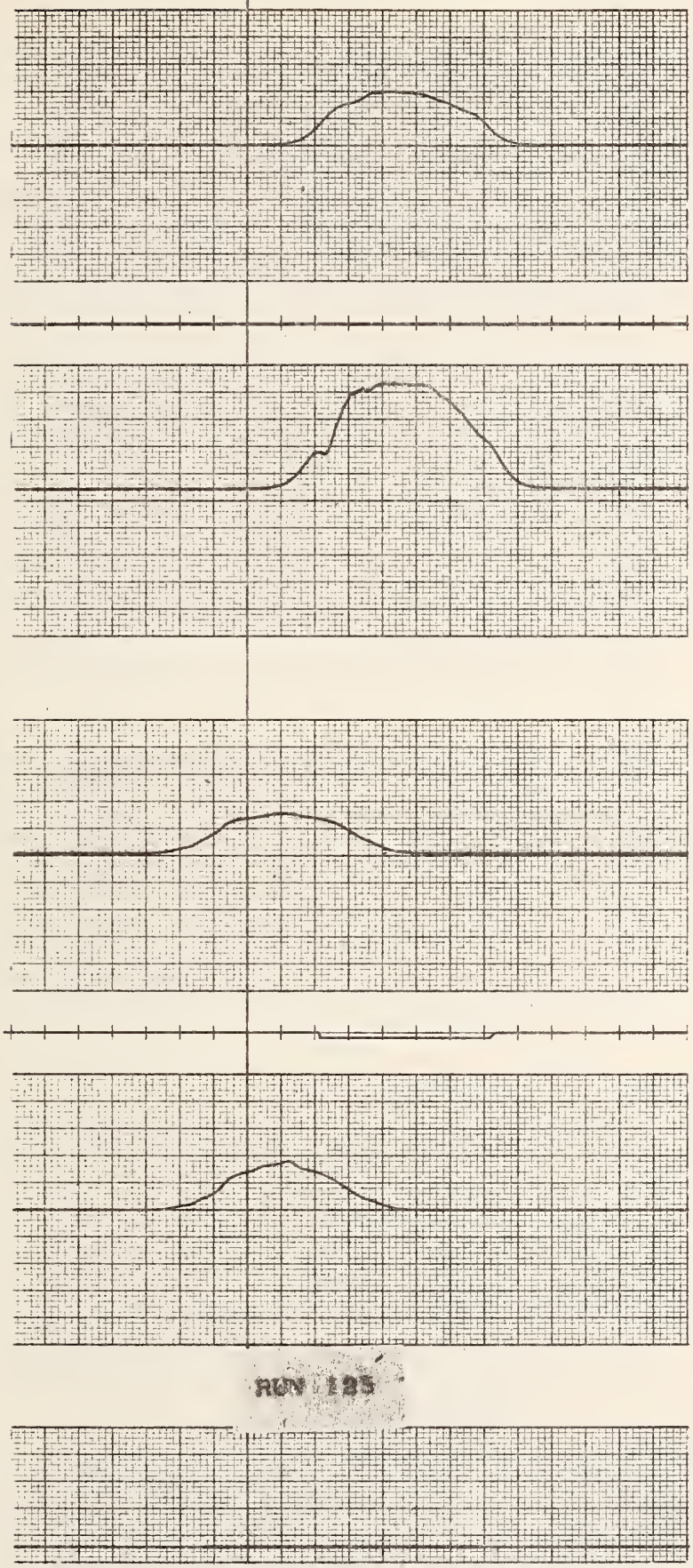

RUN 121

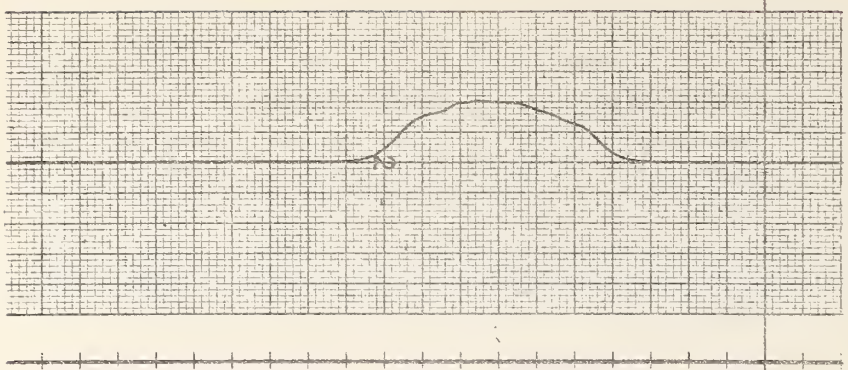


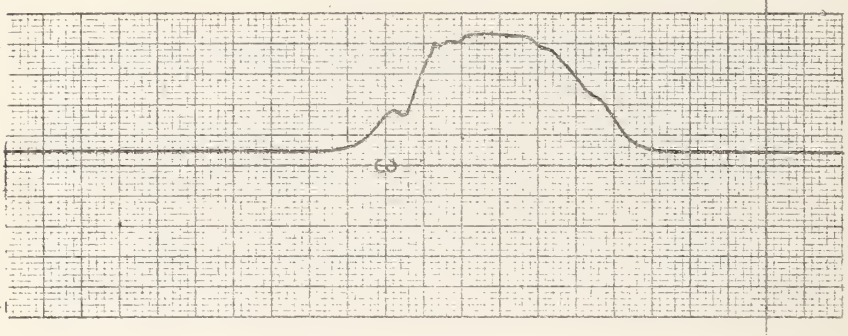
RUN 122


Gould Inc., Instrument Syst
ACCUCHART
Cleveland, Ohio
Printed
RUN 123

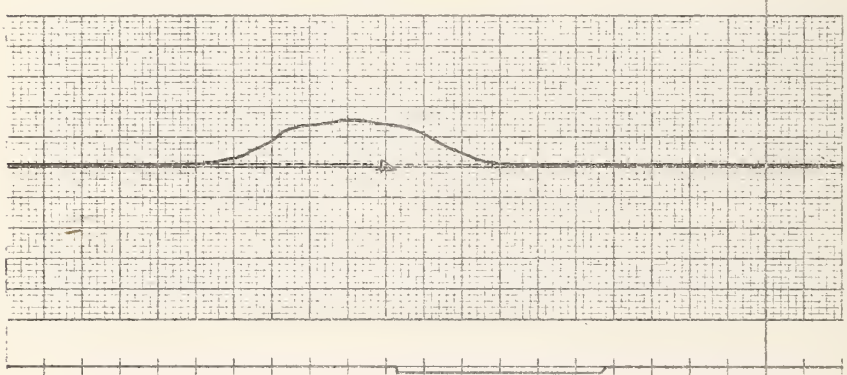

RUN 124

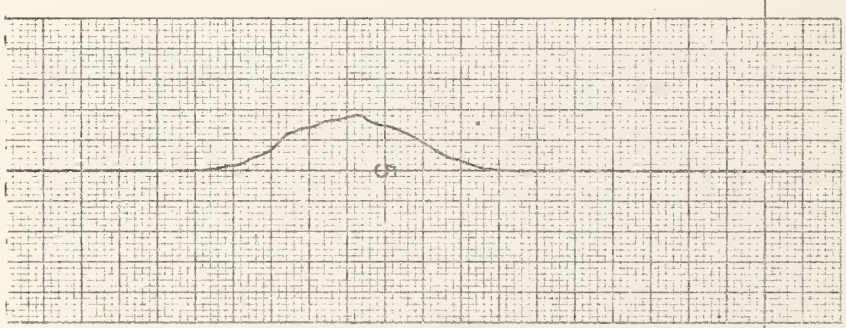

RUN 125



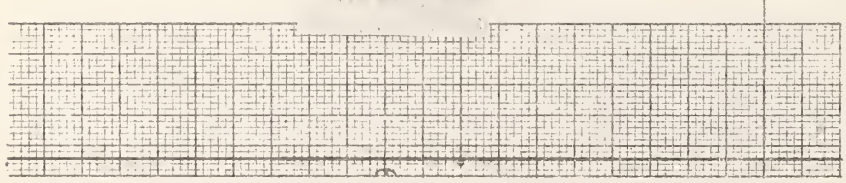


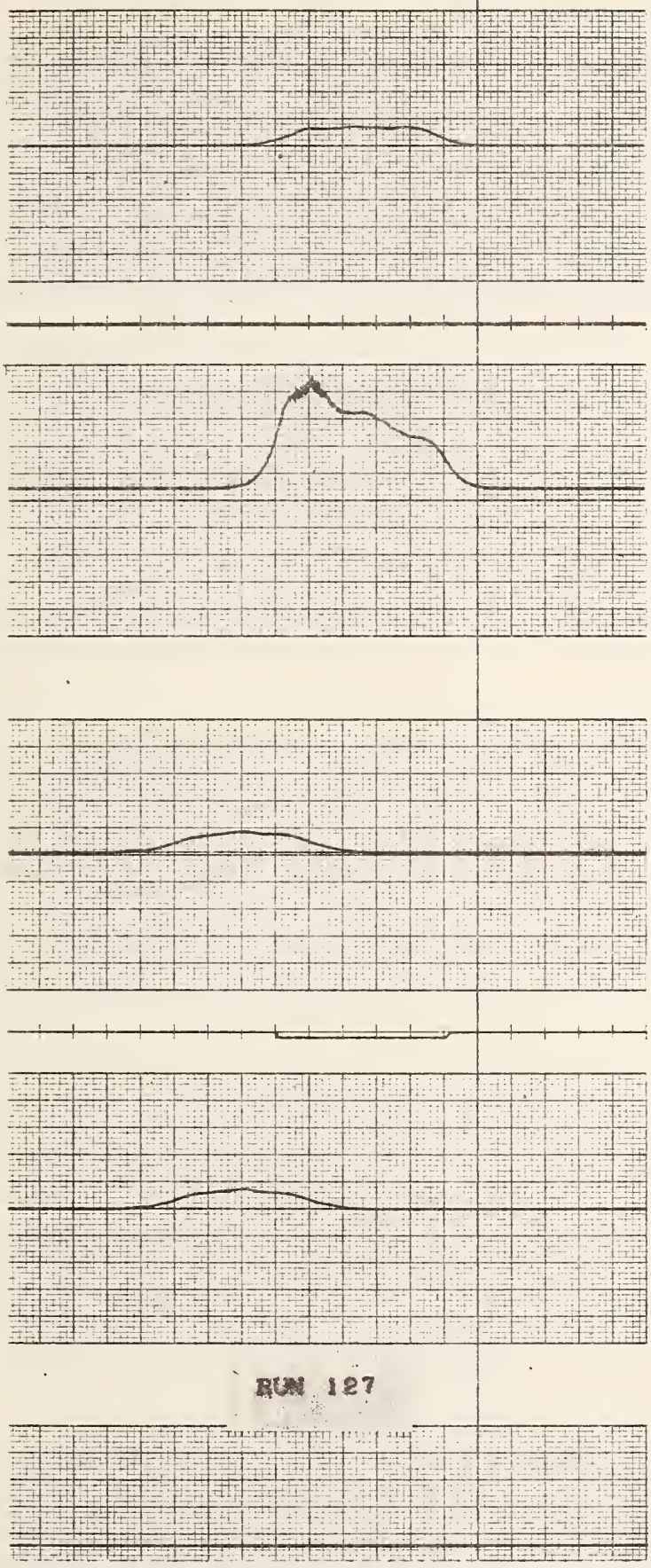
BRUSH ACCUCHART



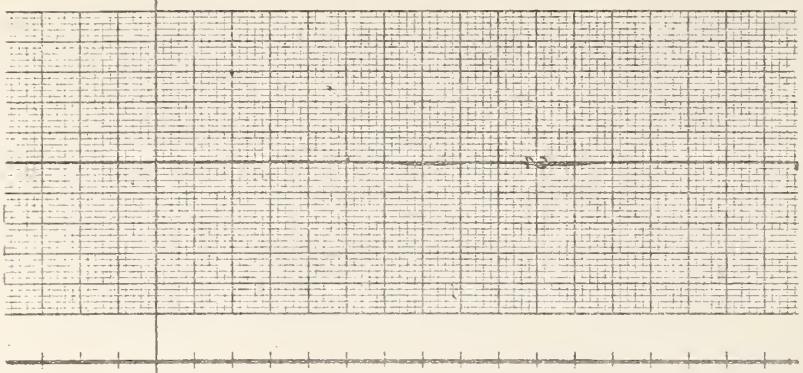


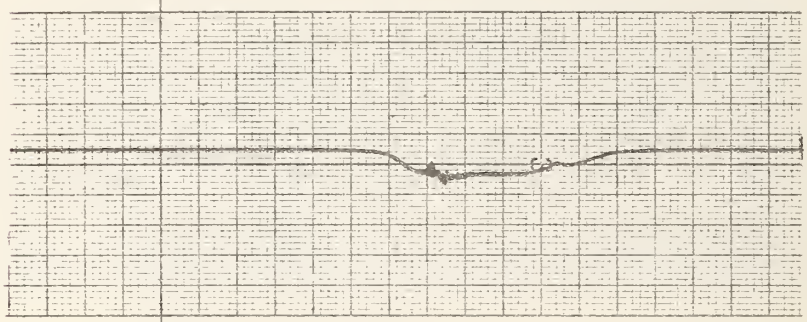
RUN 126

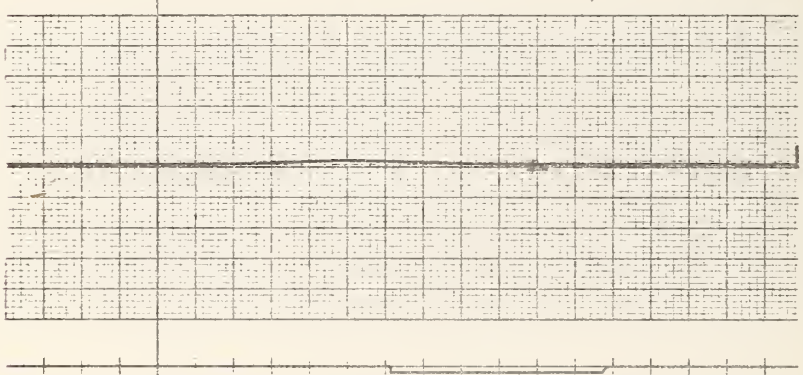


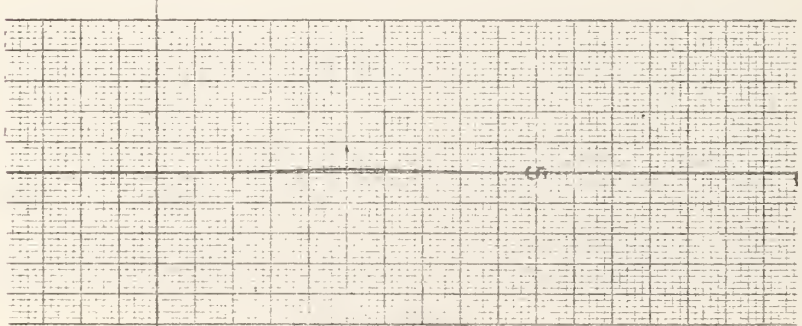


RUN 127

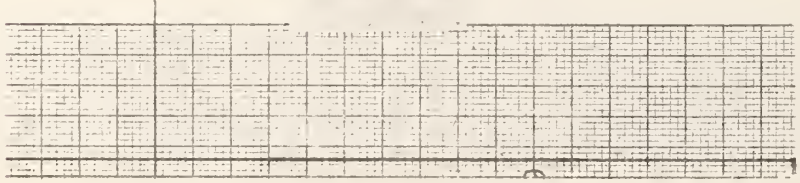


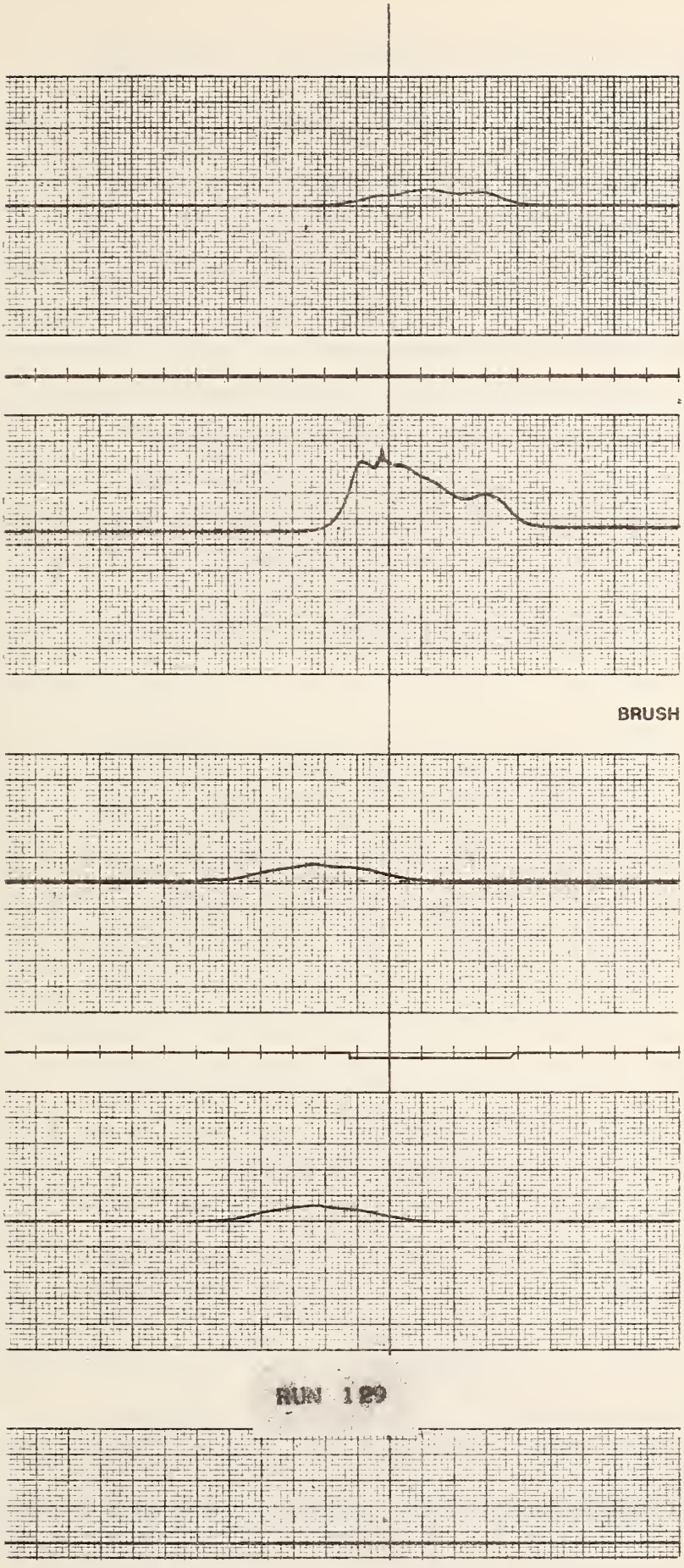


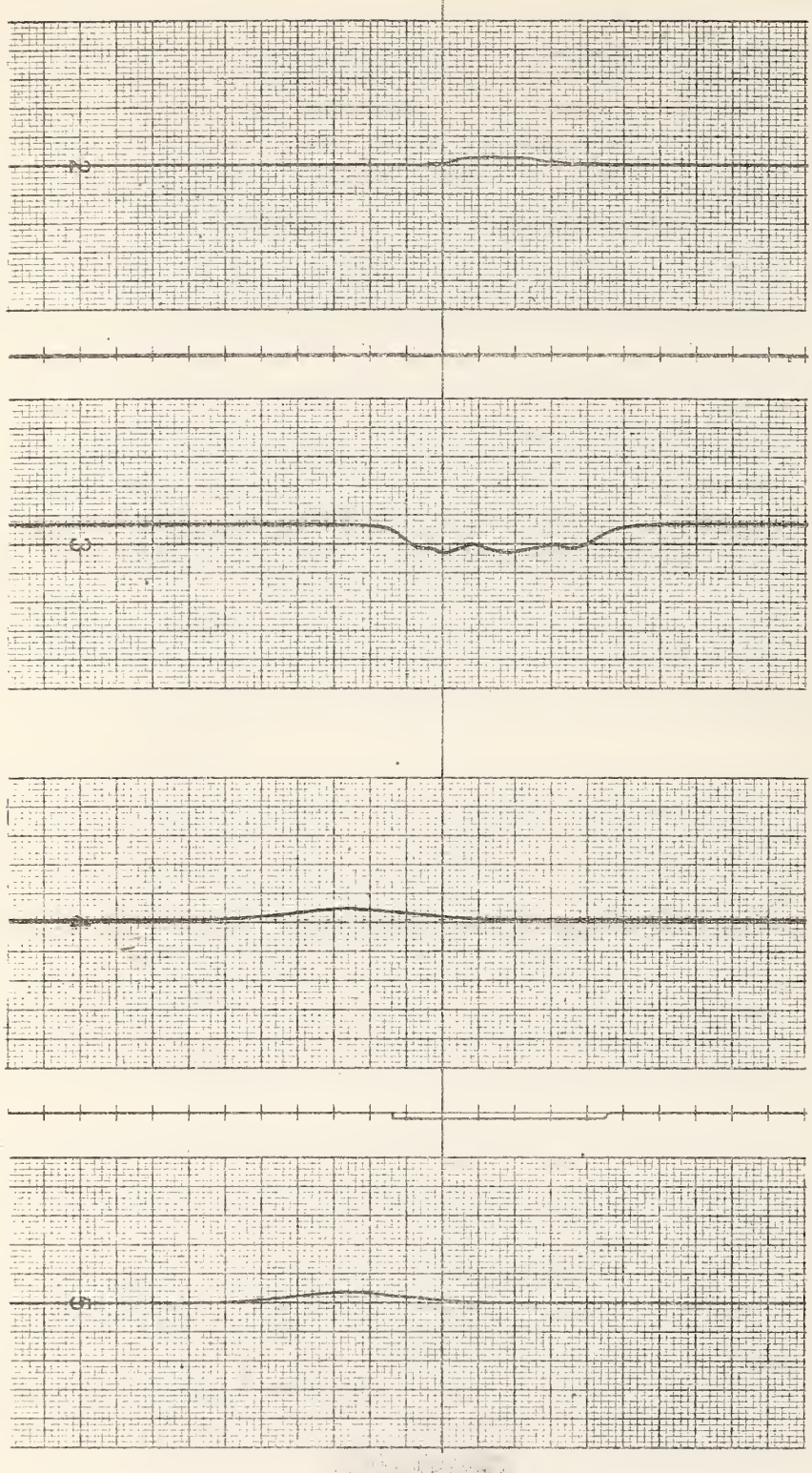


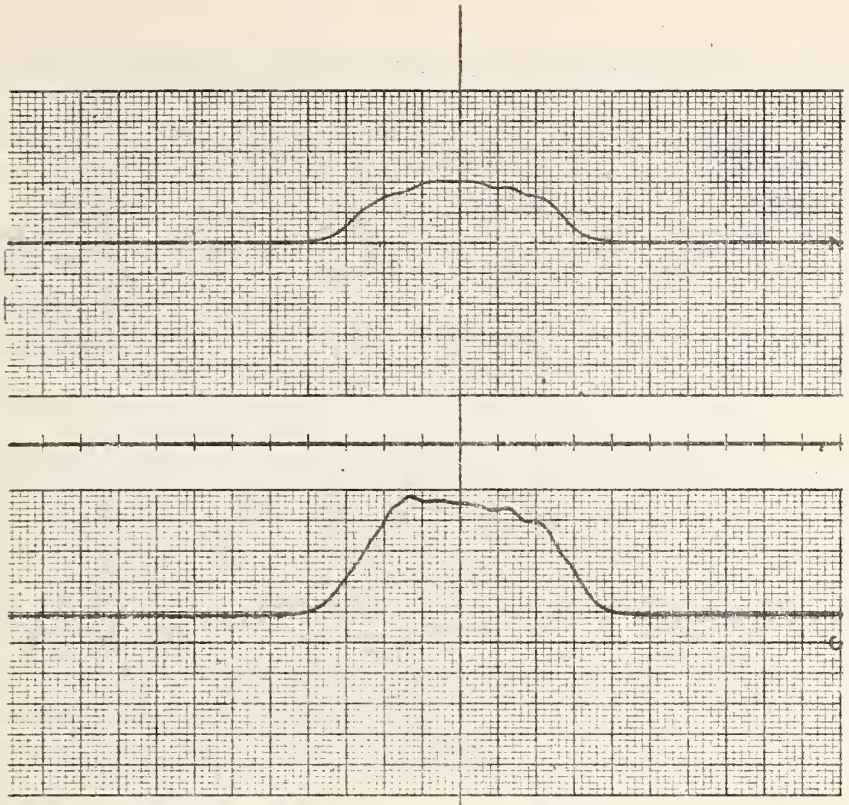


RUN 128




BRUSH
RUN 129


RUN 130



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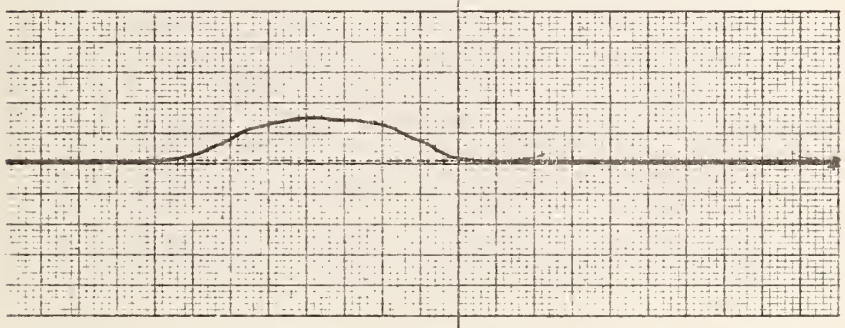
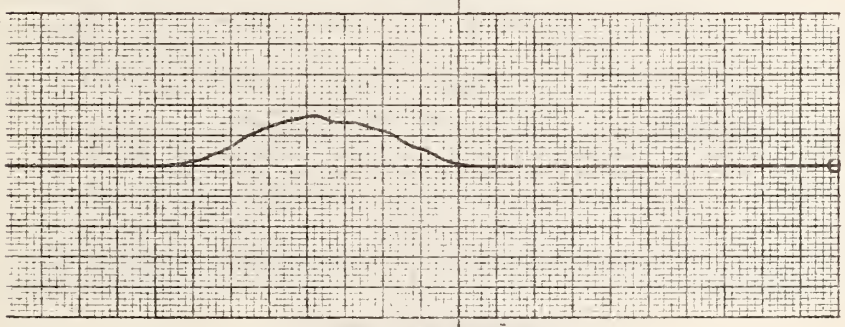
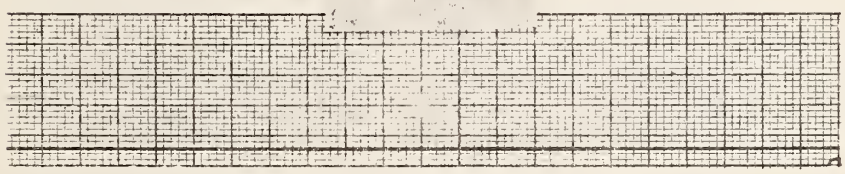
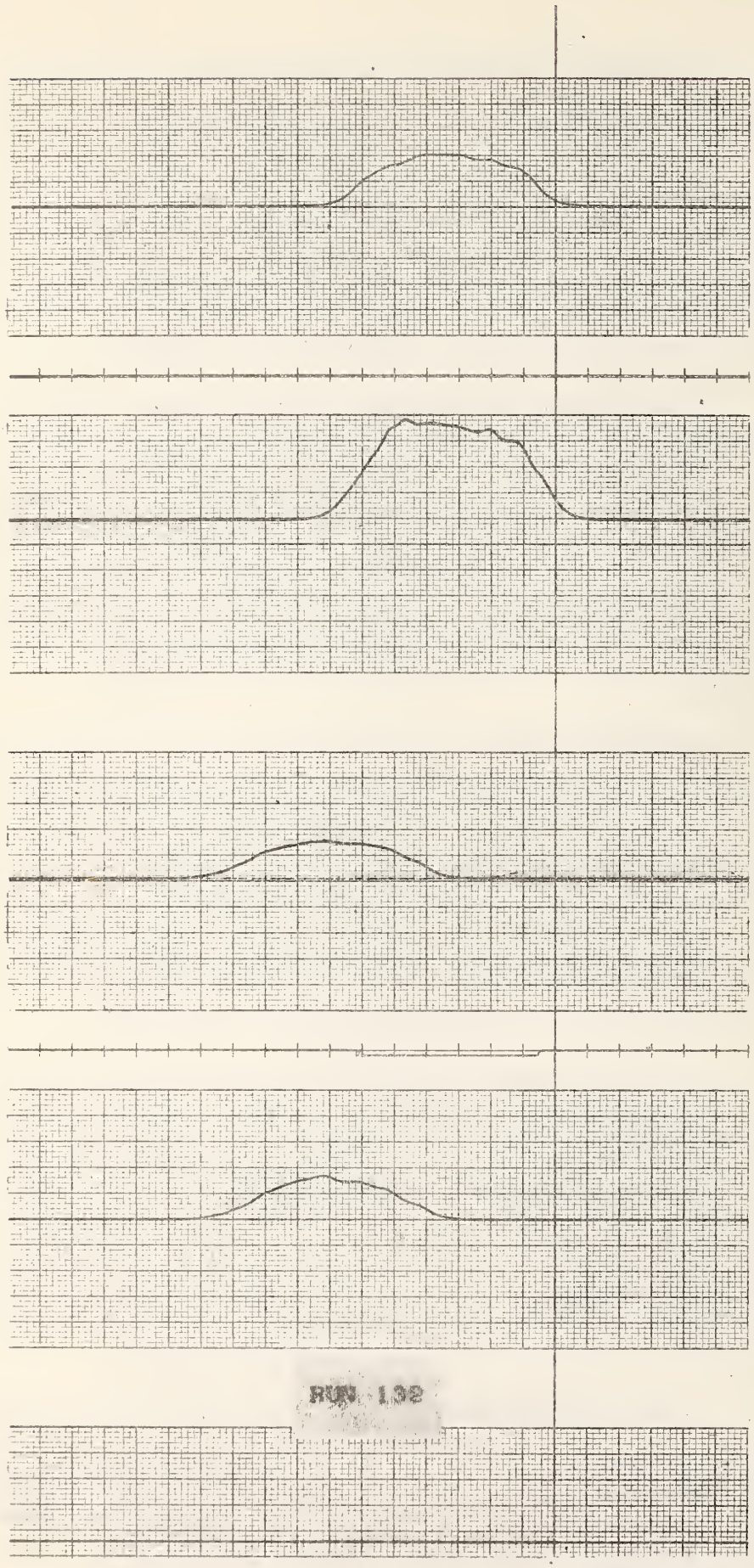
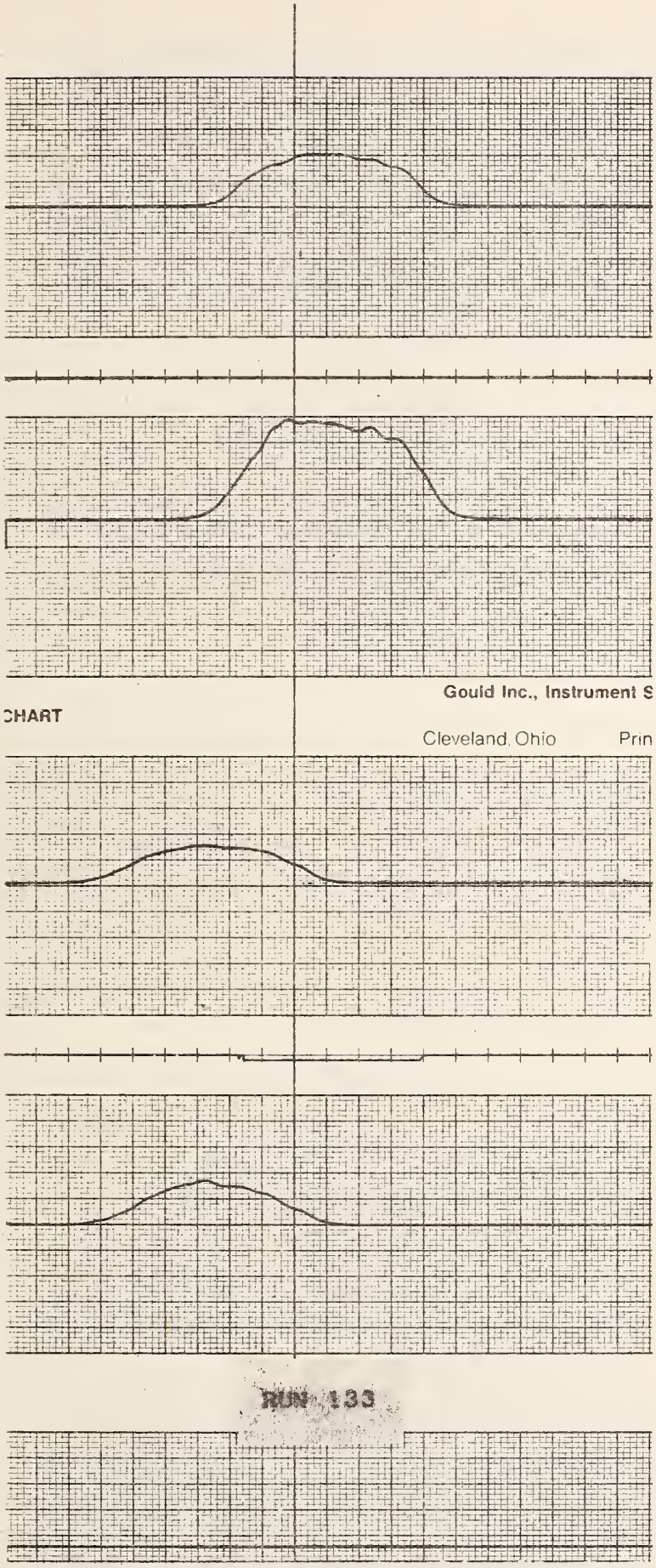




RUN 131




RUN 132


Gould Inc., Instrument S
CHART
Cleveland, Ohio
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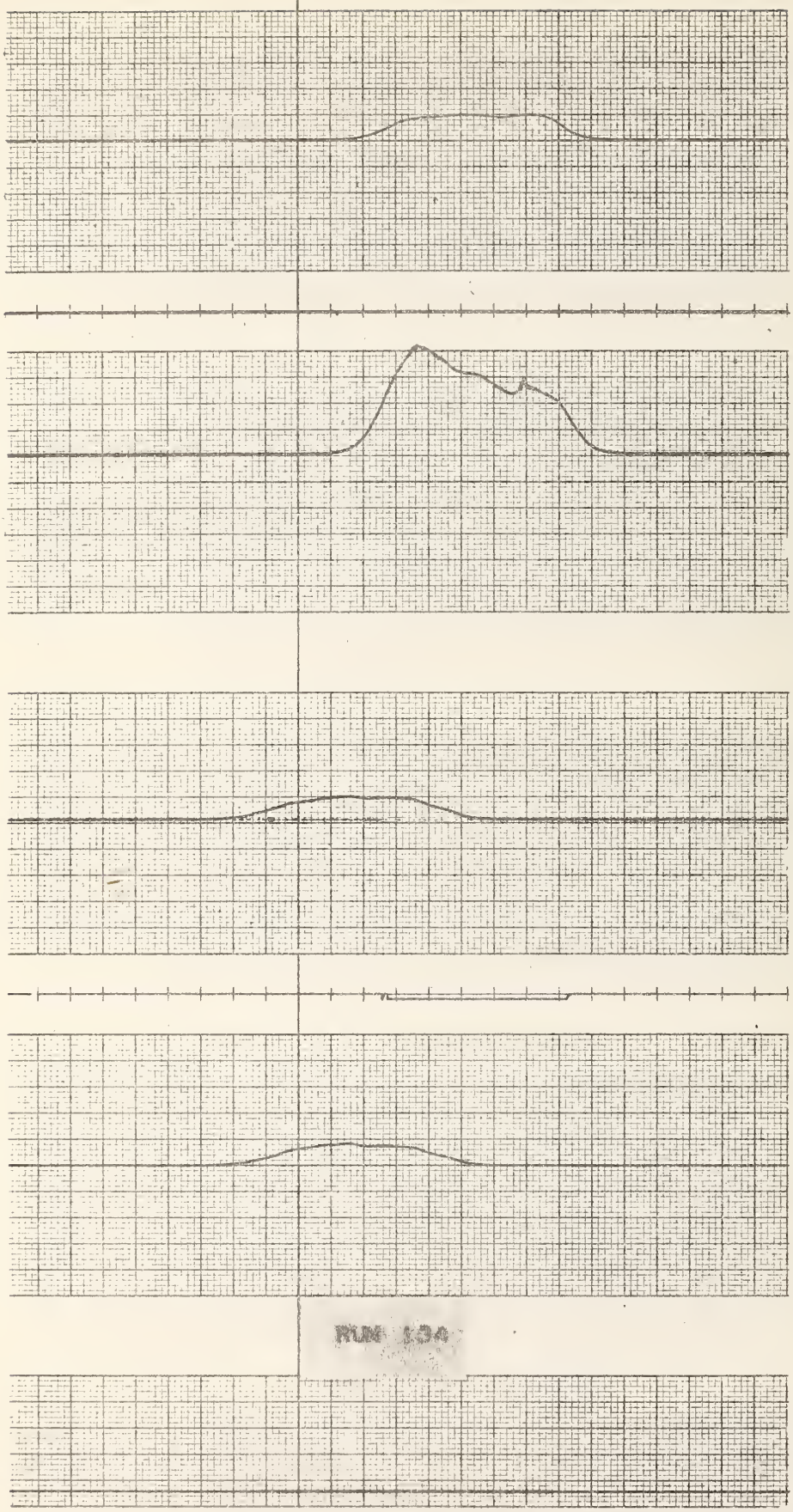
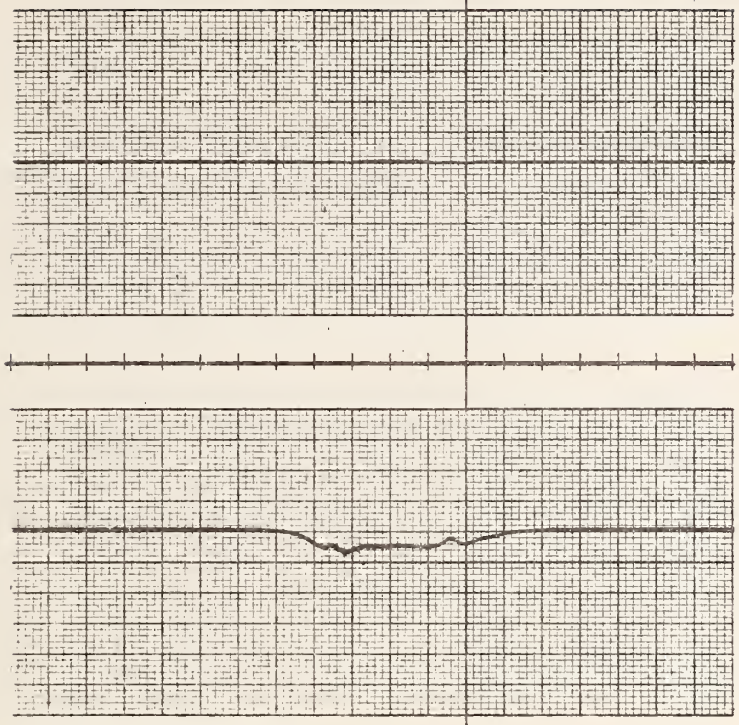
RUN 133


RUN 134



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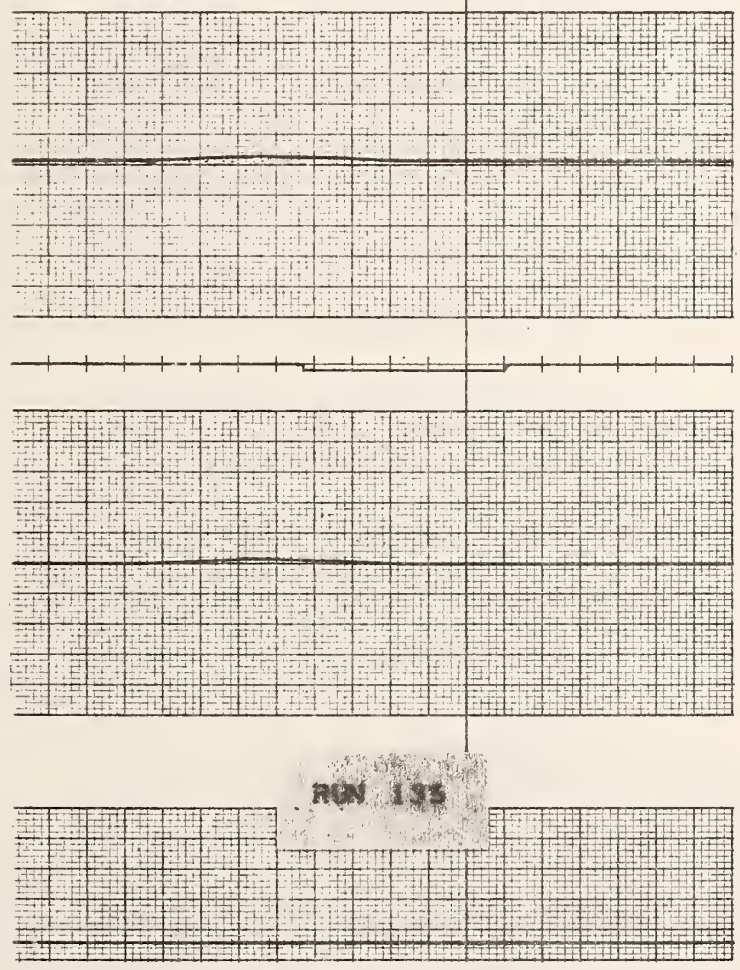
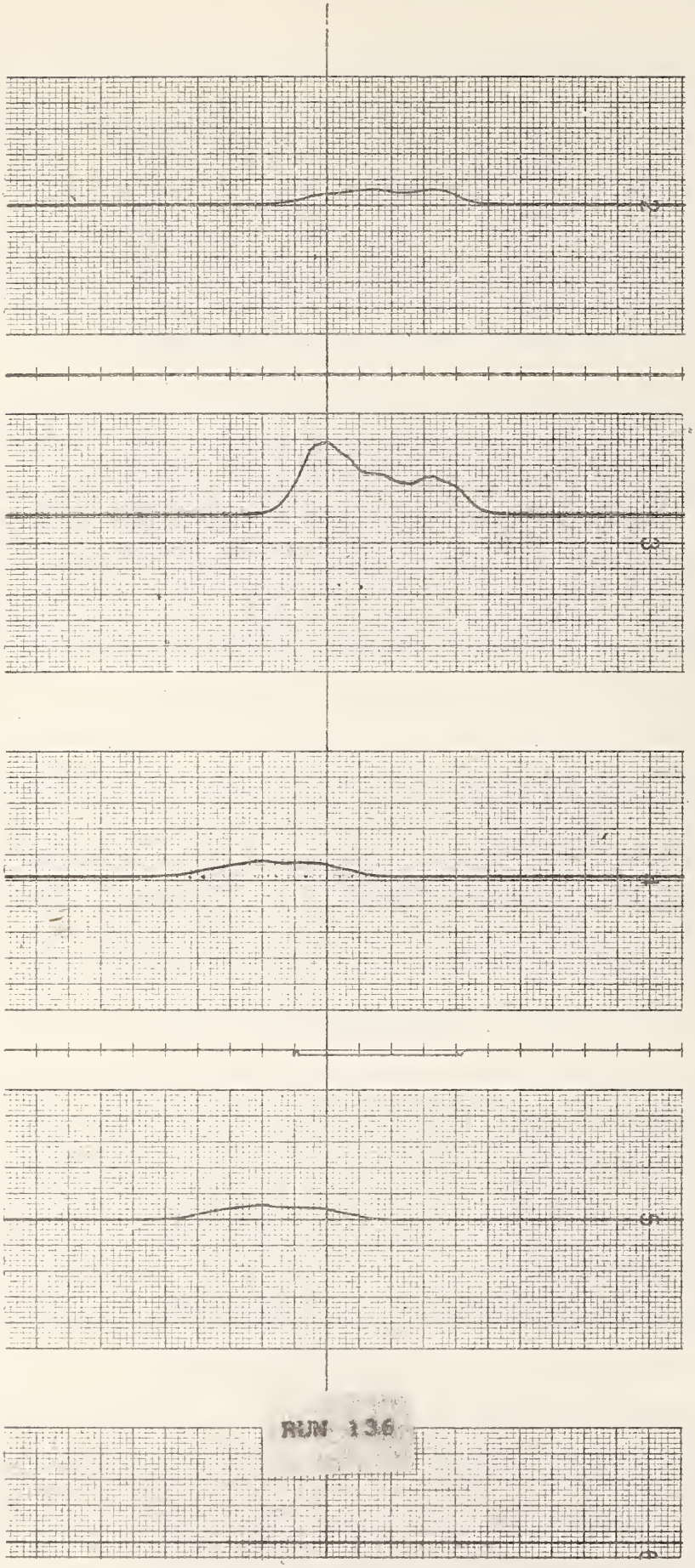
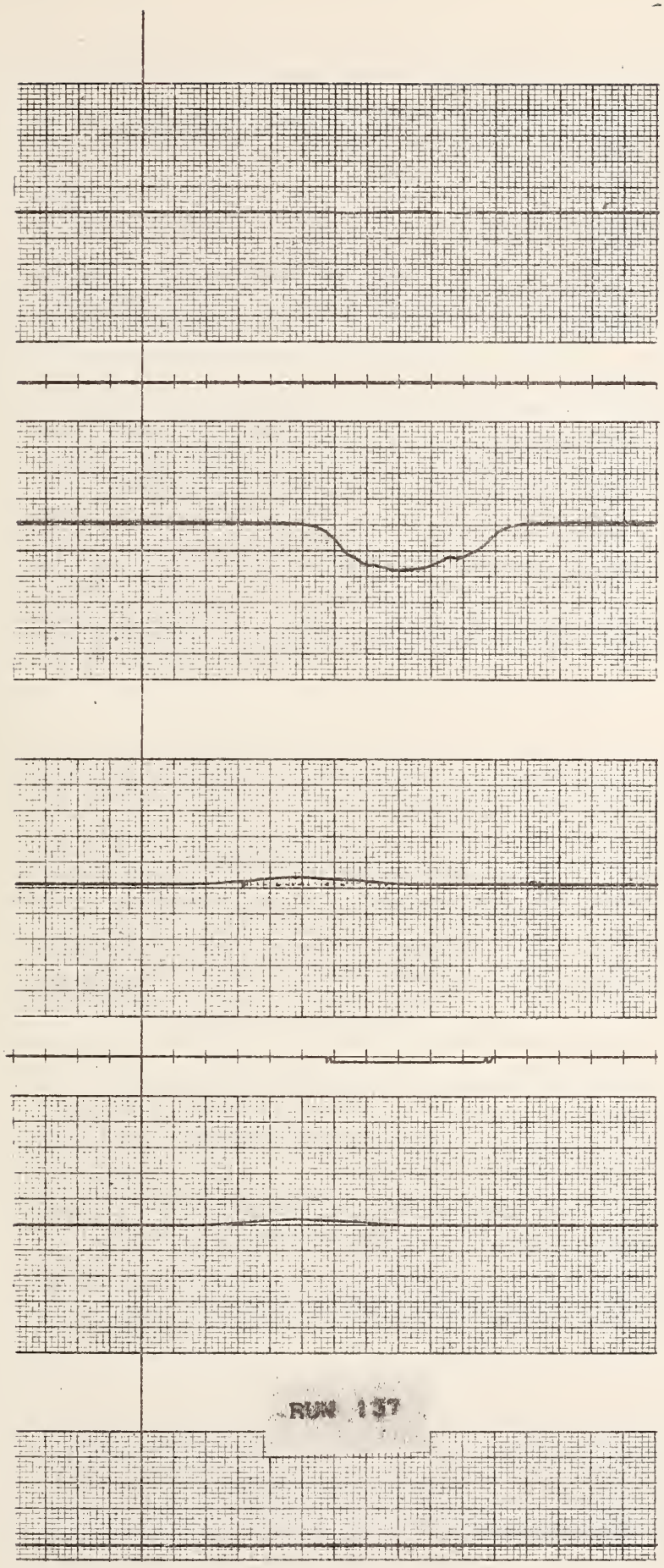
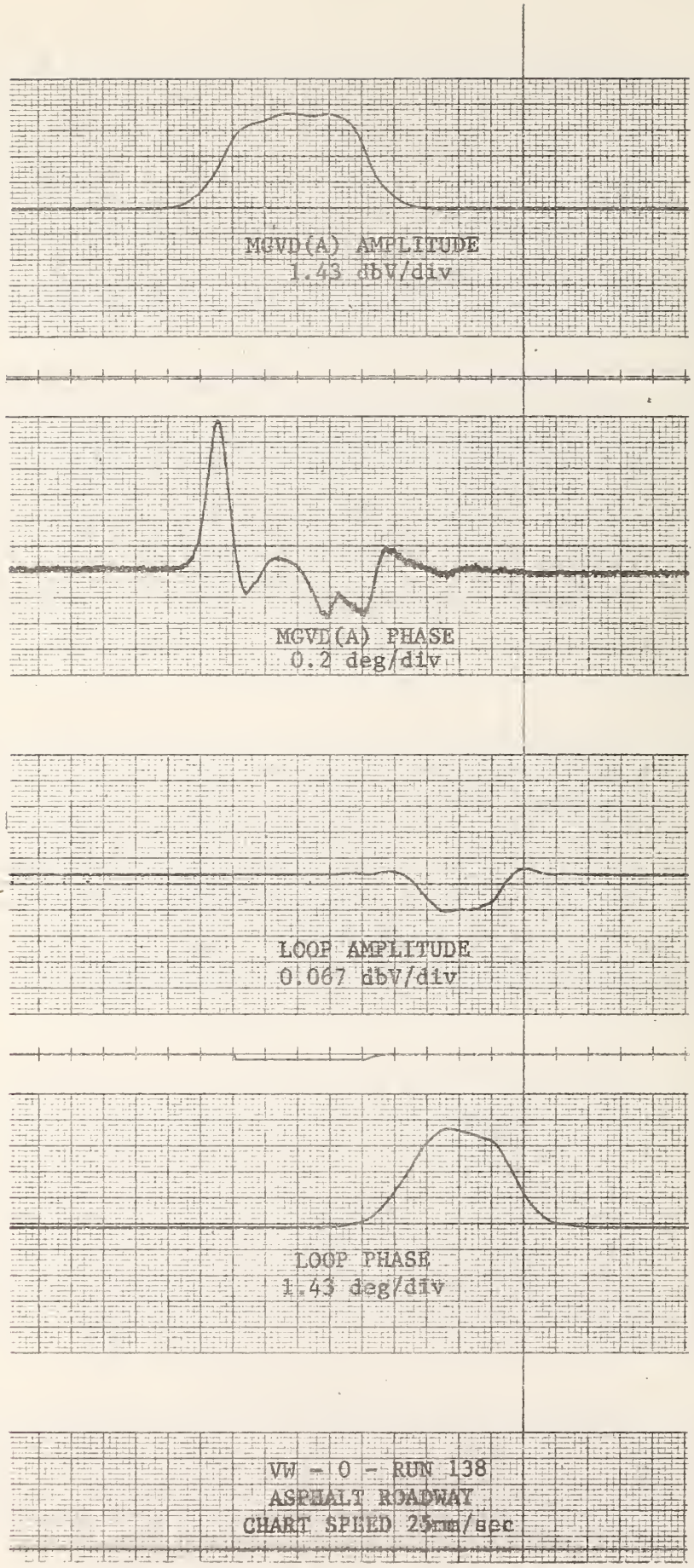
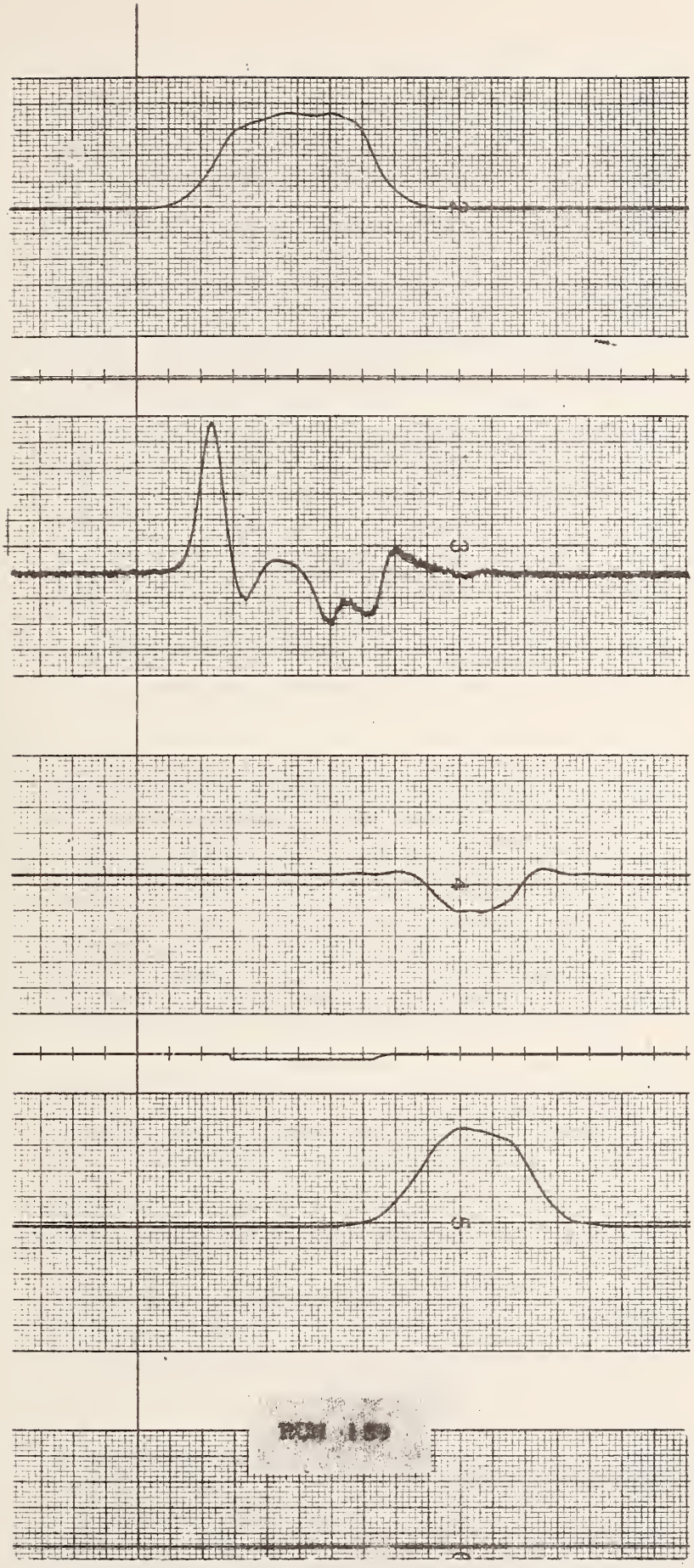


RON 133


RUN 136


RUN 137


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
VW - 0 - RUN 138
ASPHALT ROADWAY
CHART SPEED 25mm/sec



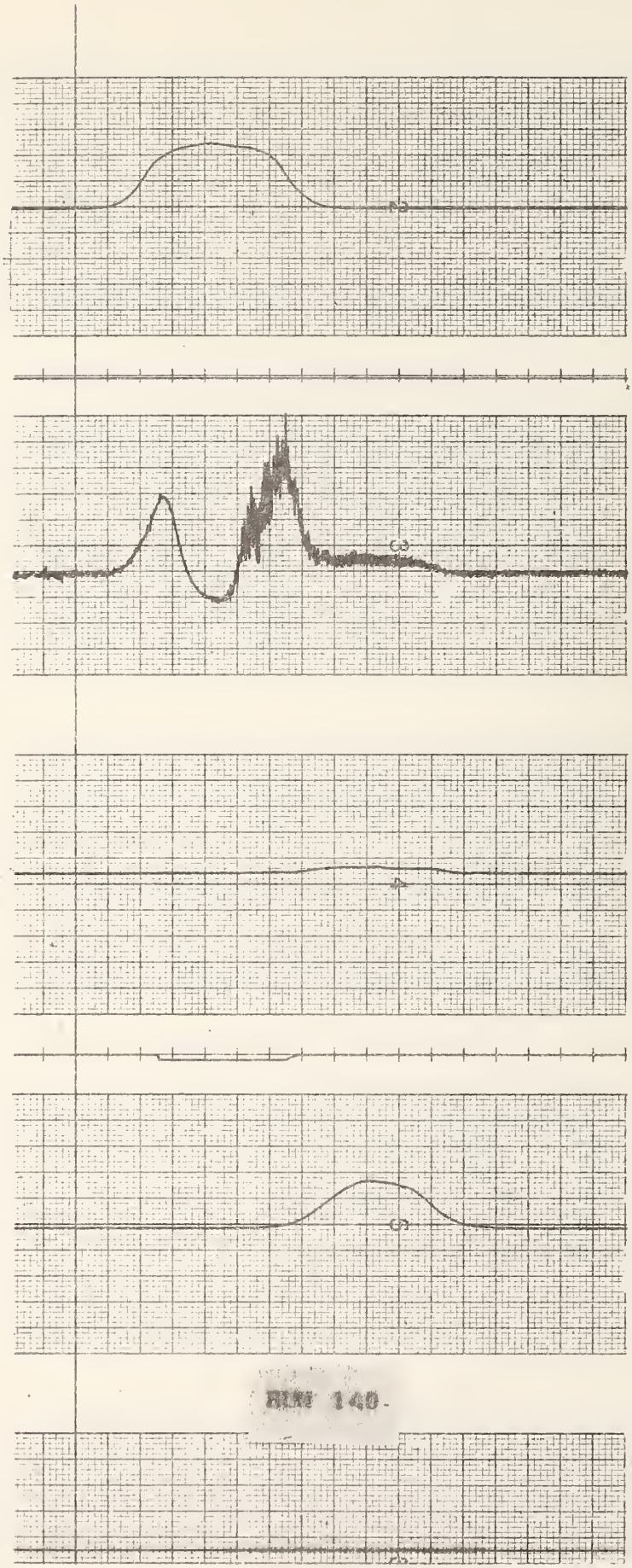
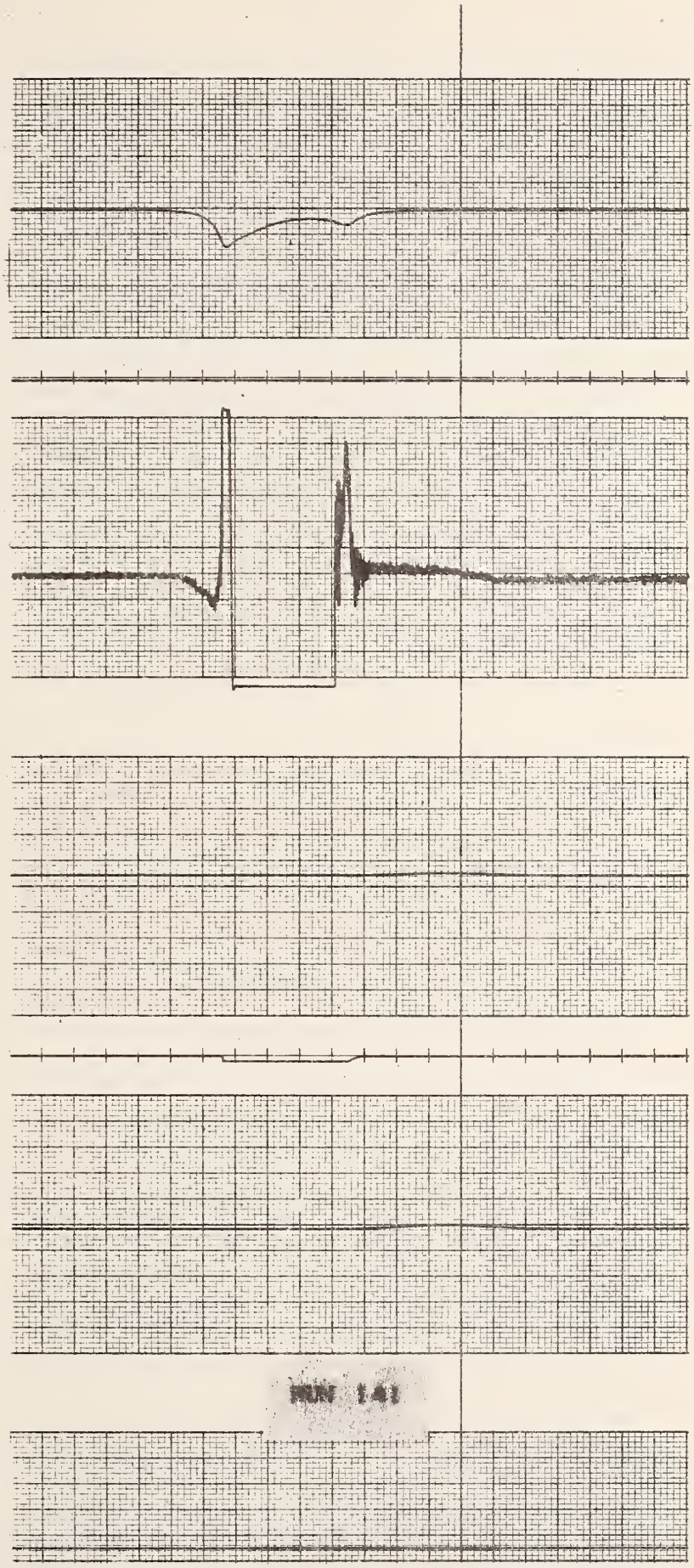
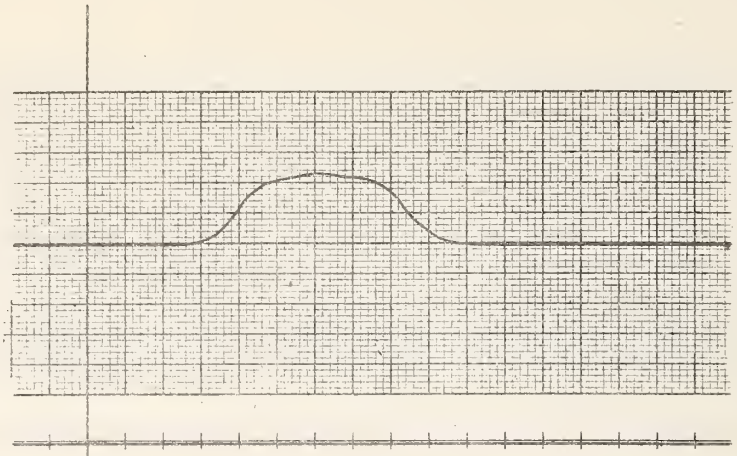
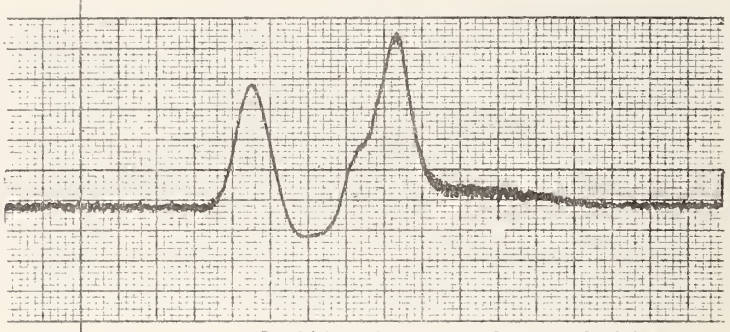


FIG 140.



RUN 141





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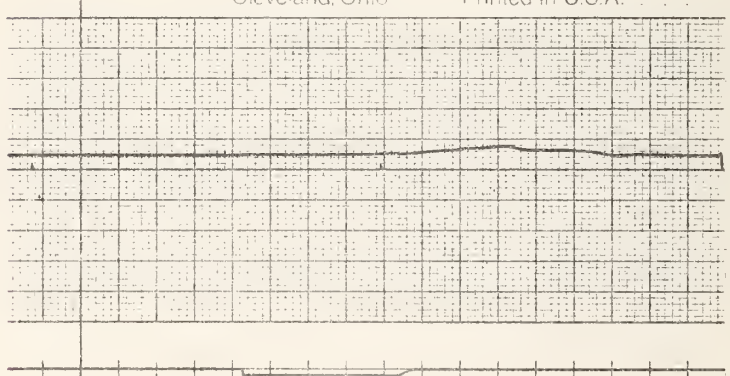
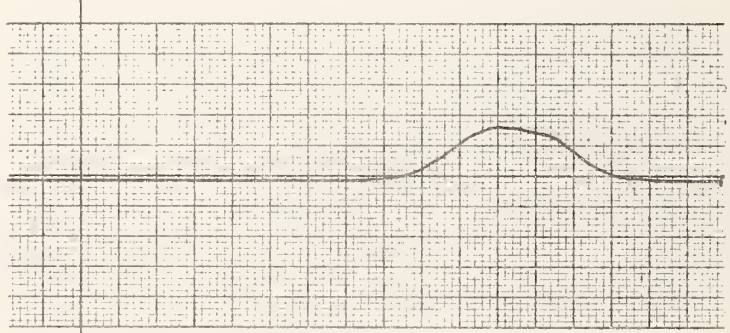
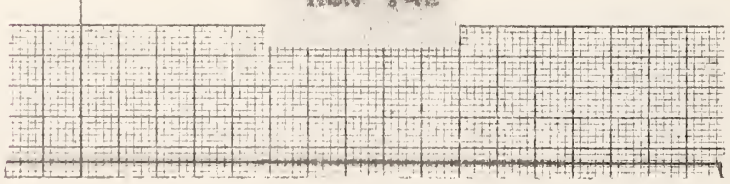
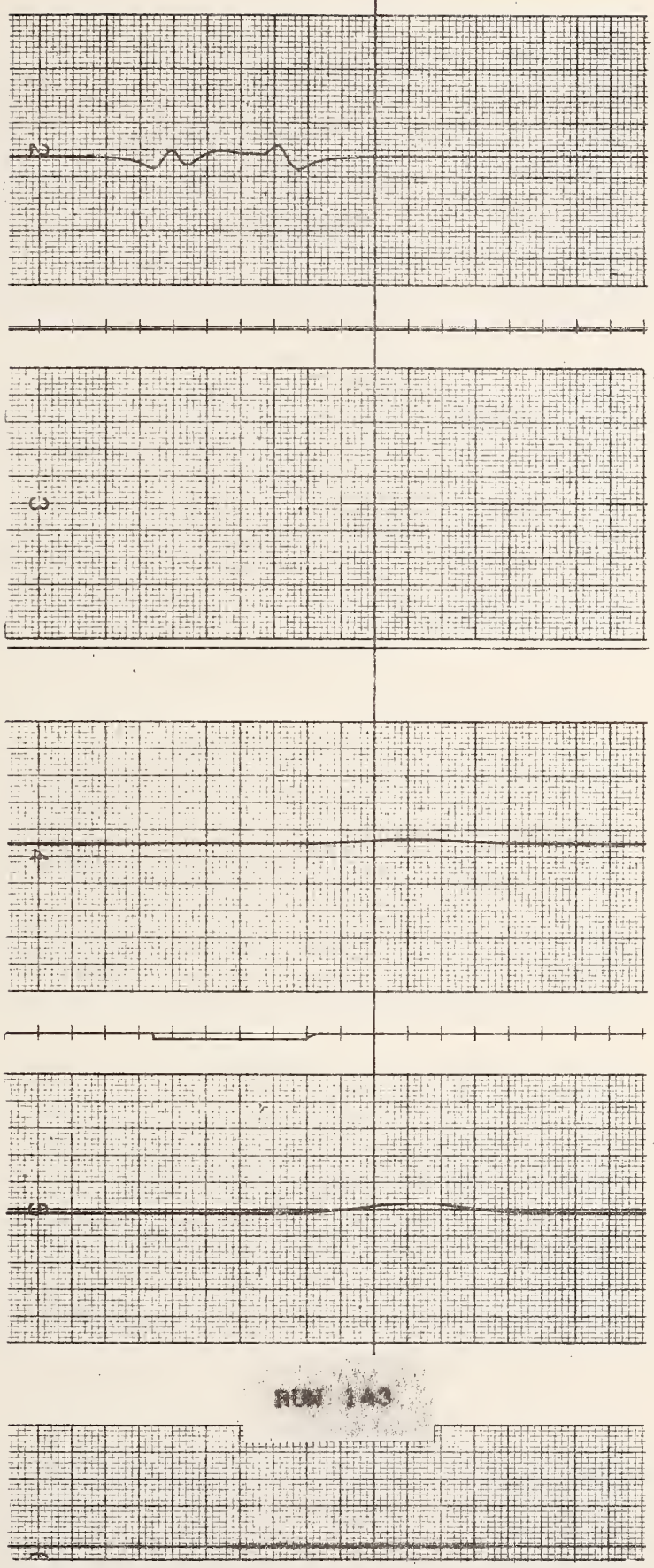


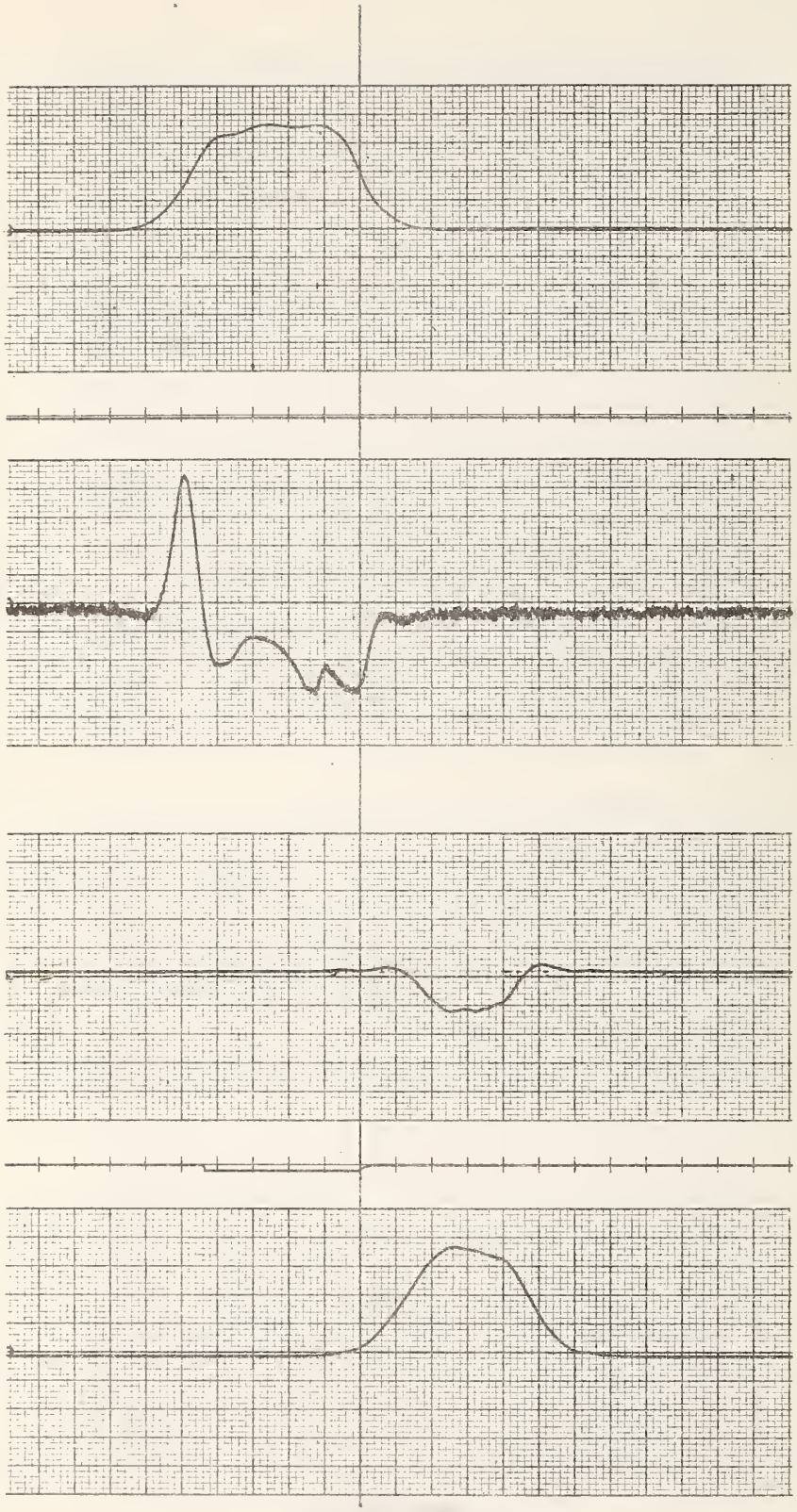


RUN 142

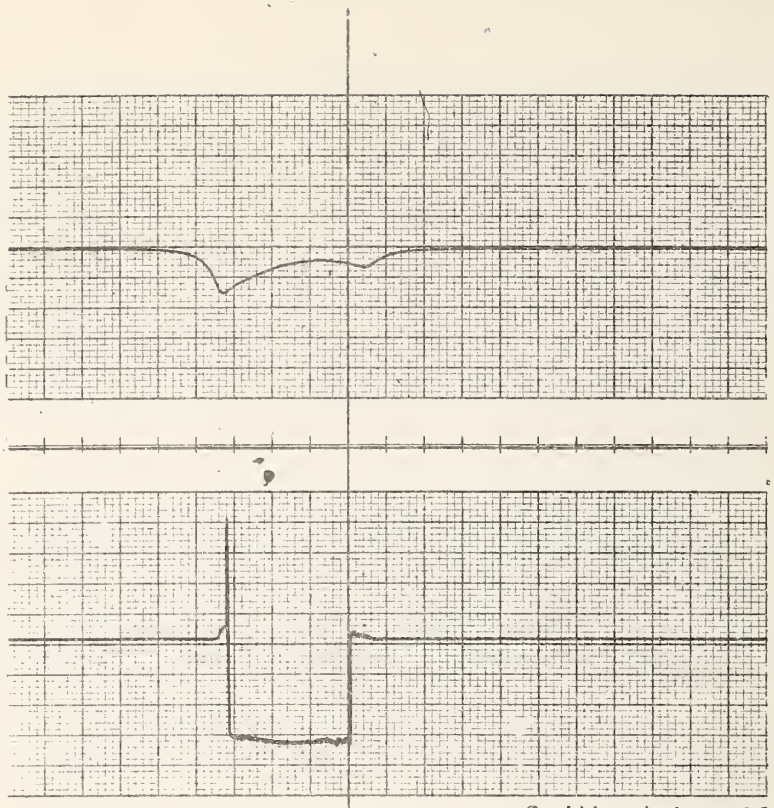




RUN 143



RUN 145



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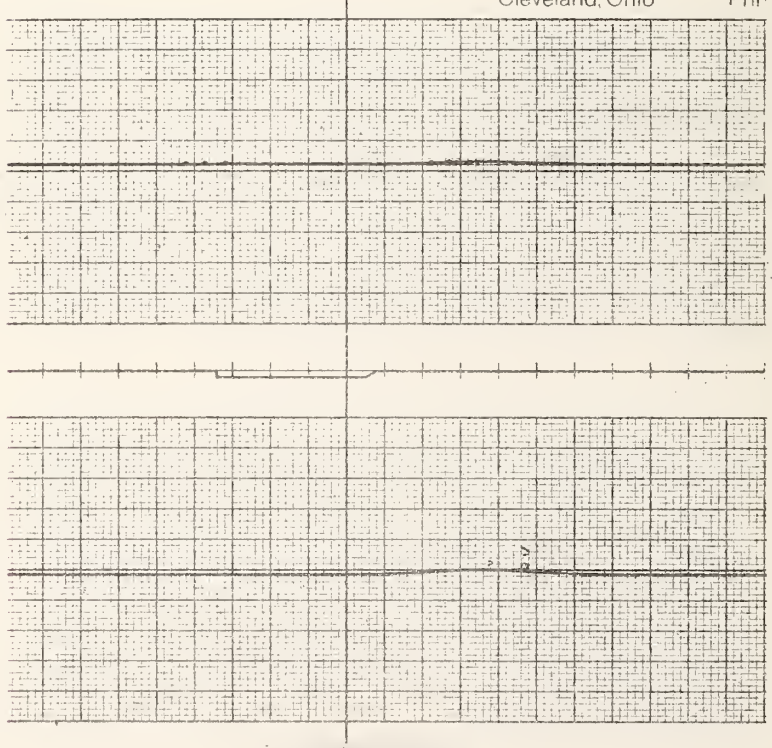
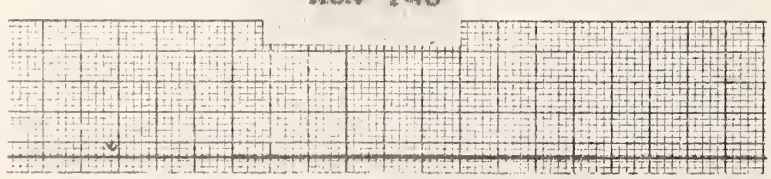
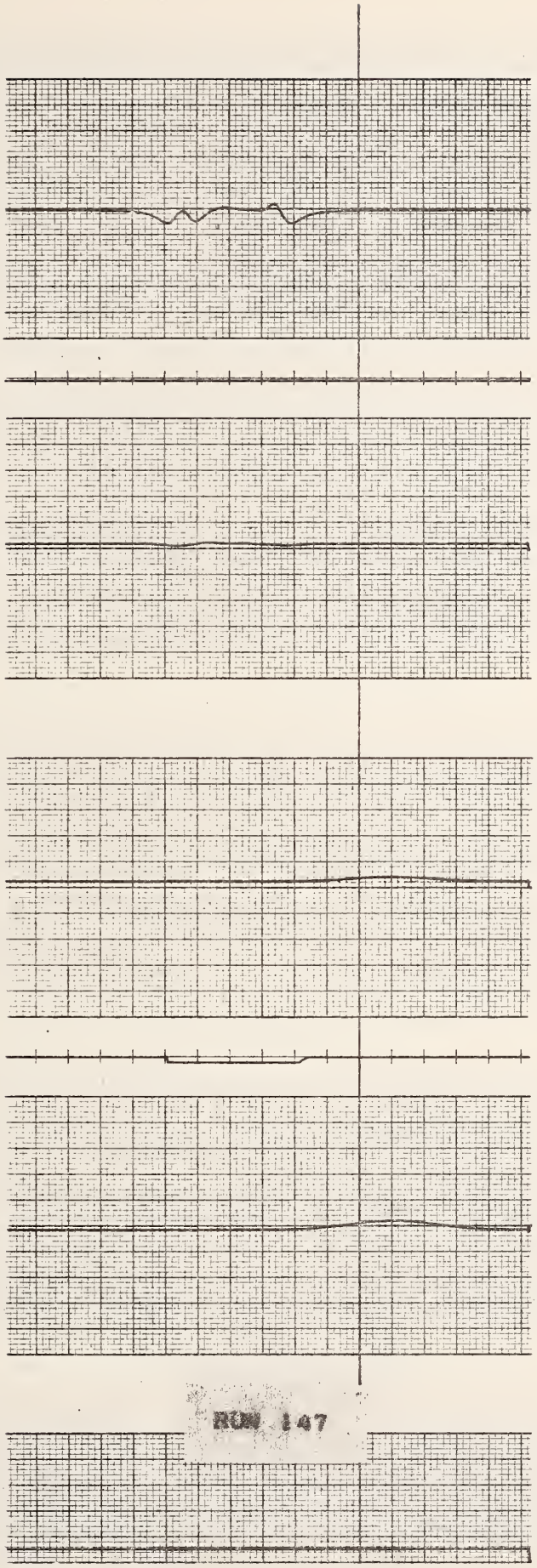
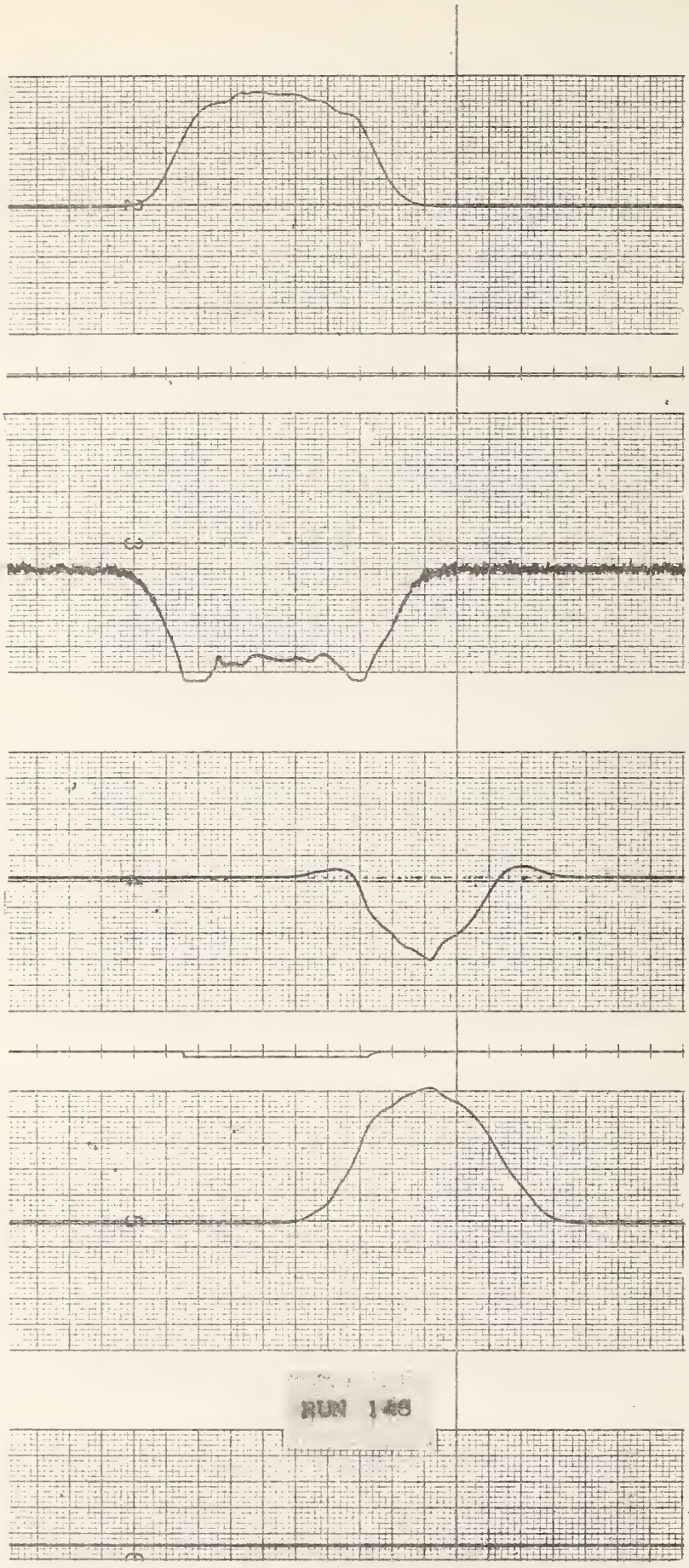
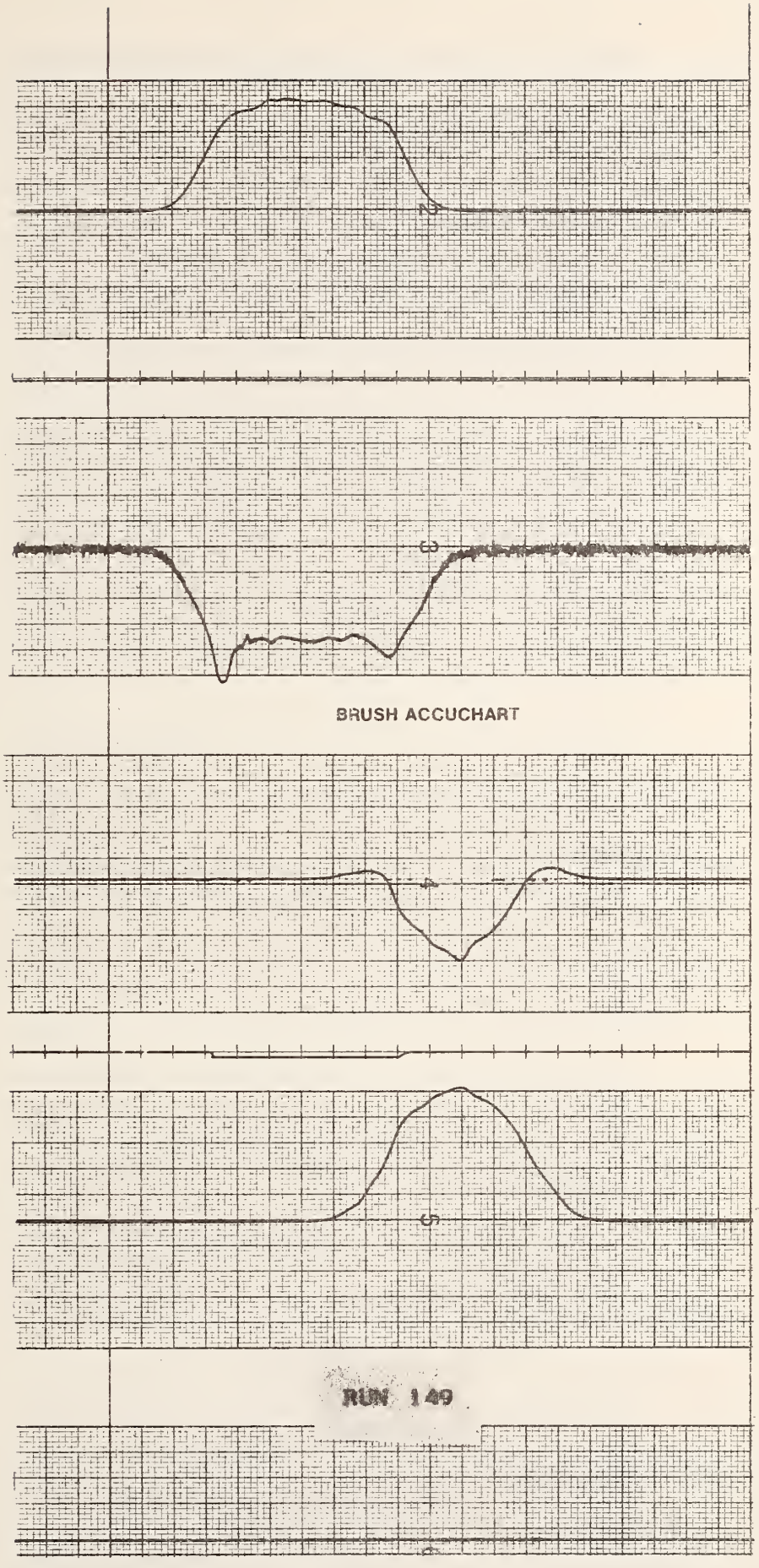


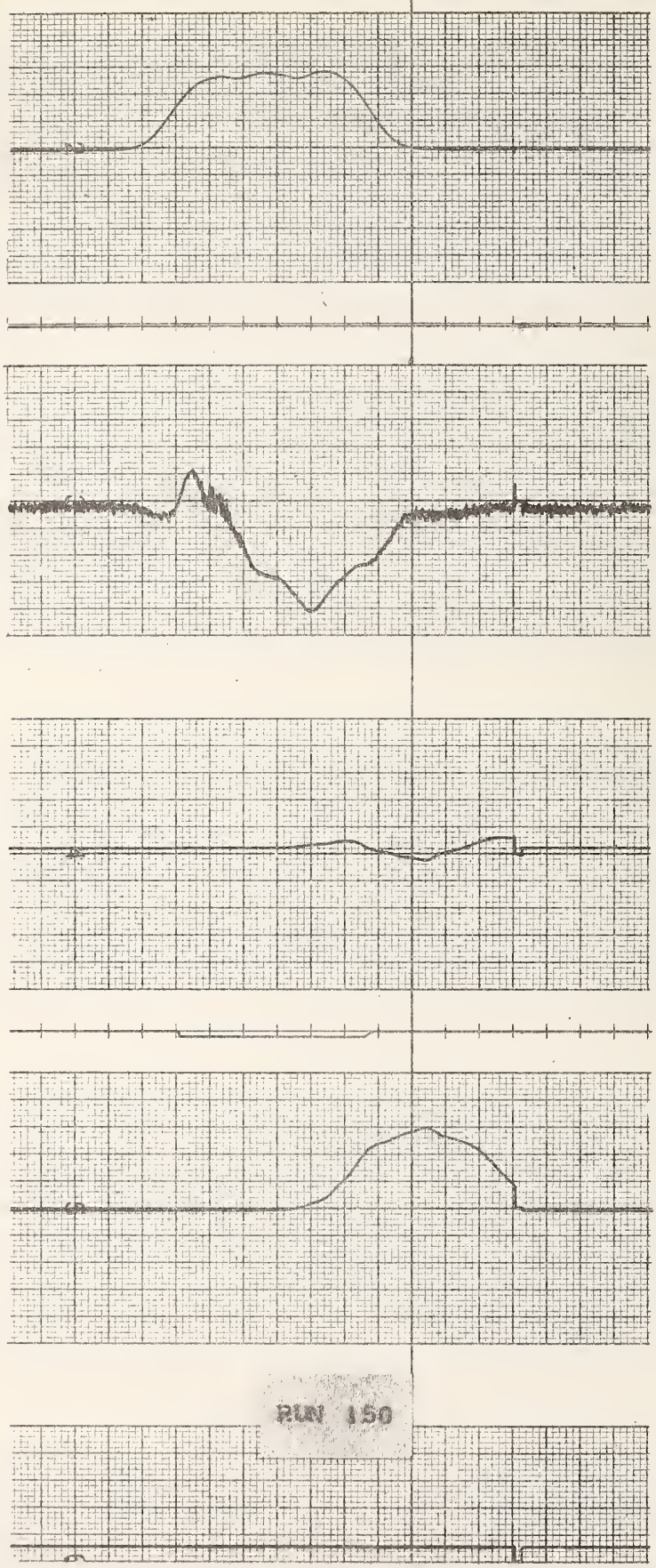
RUN 146



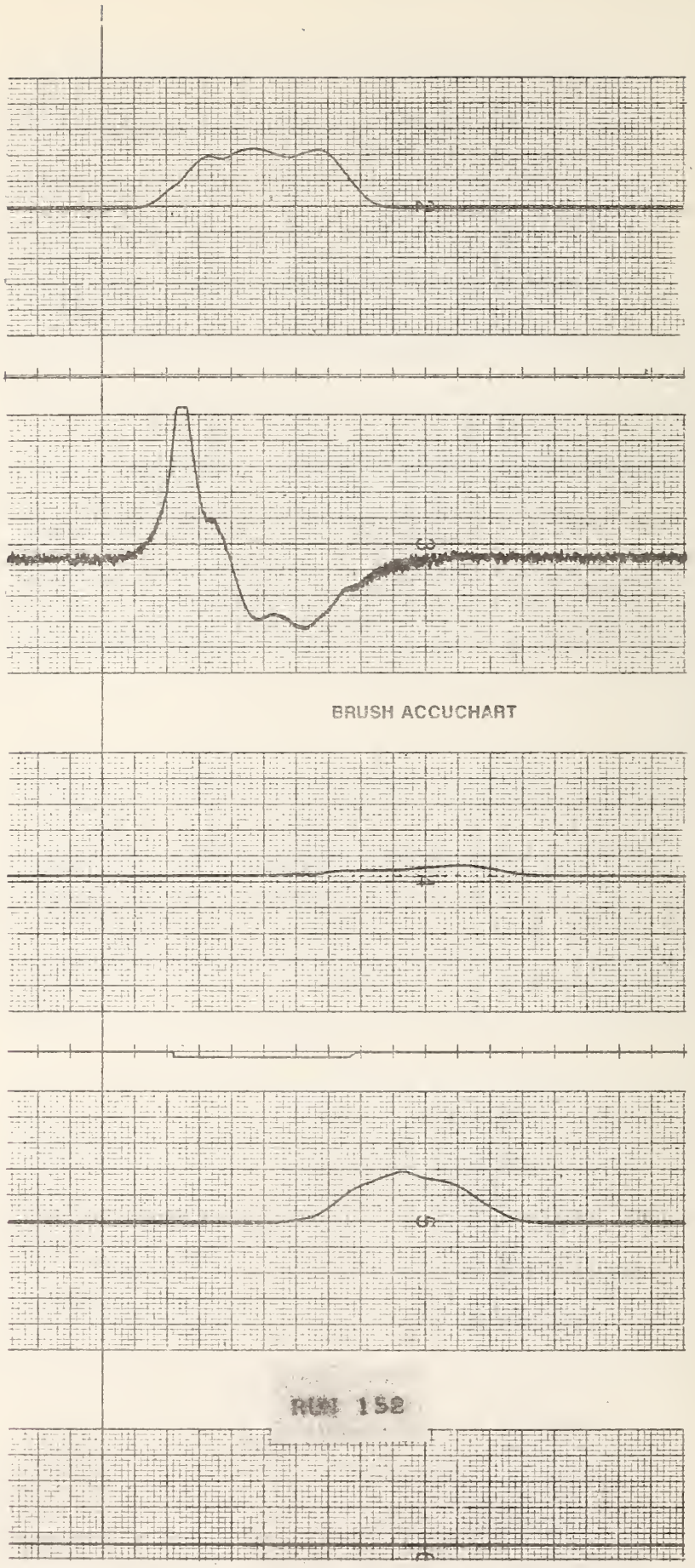

RUN 147

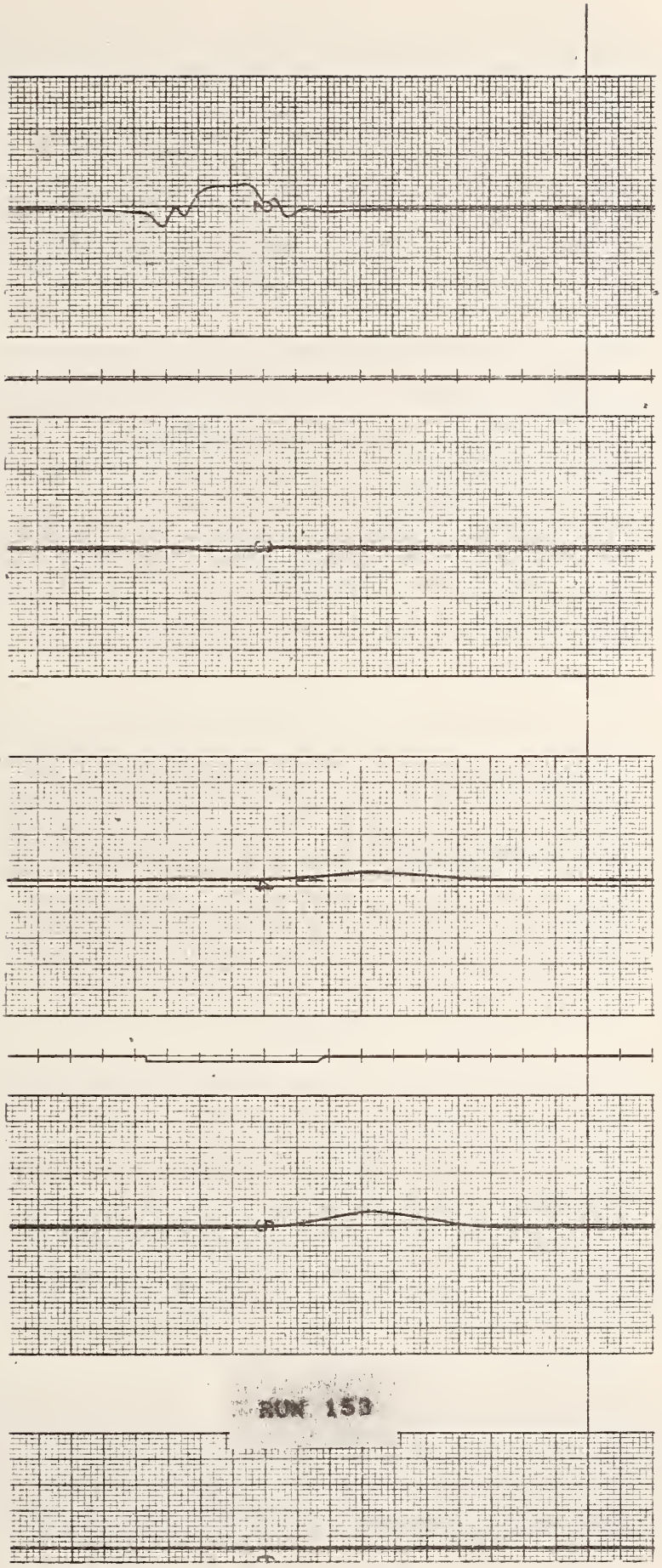

RUN 148

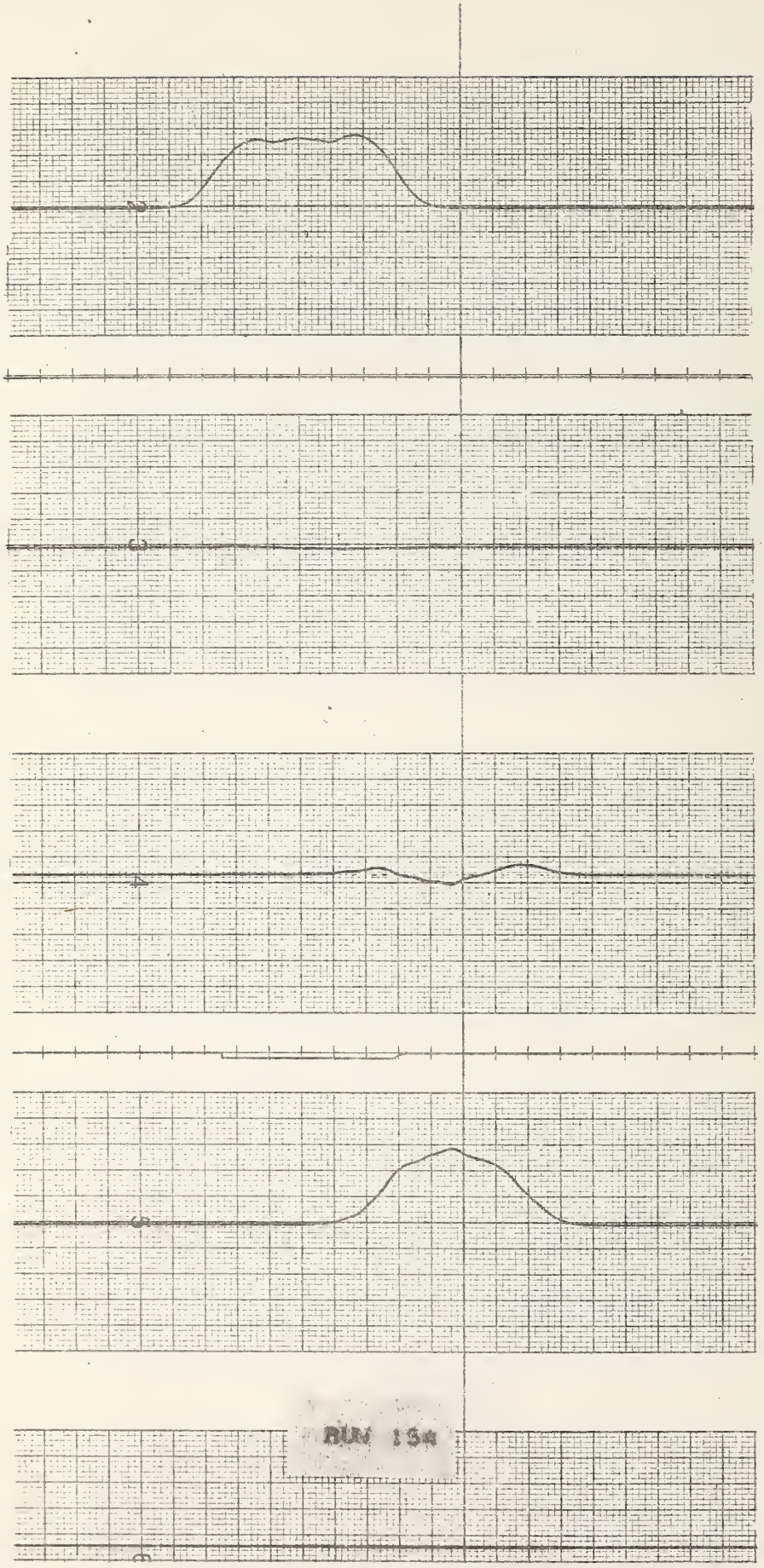

BRUSH ACCUCHART
RUN 149

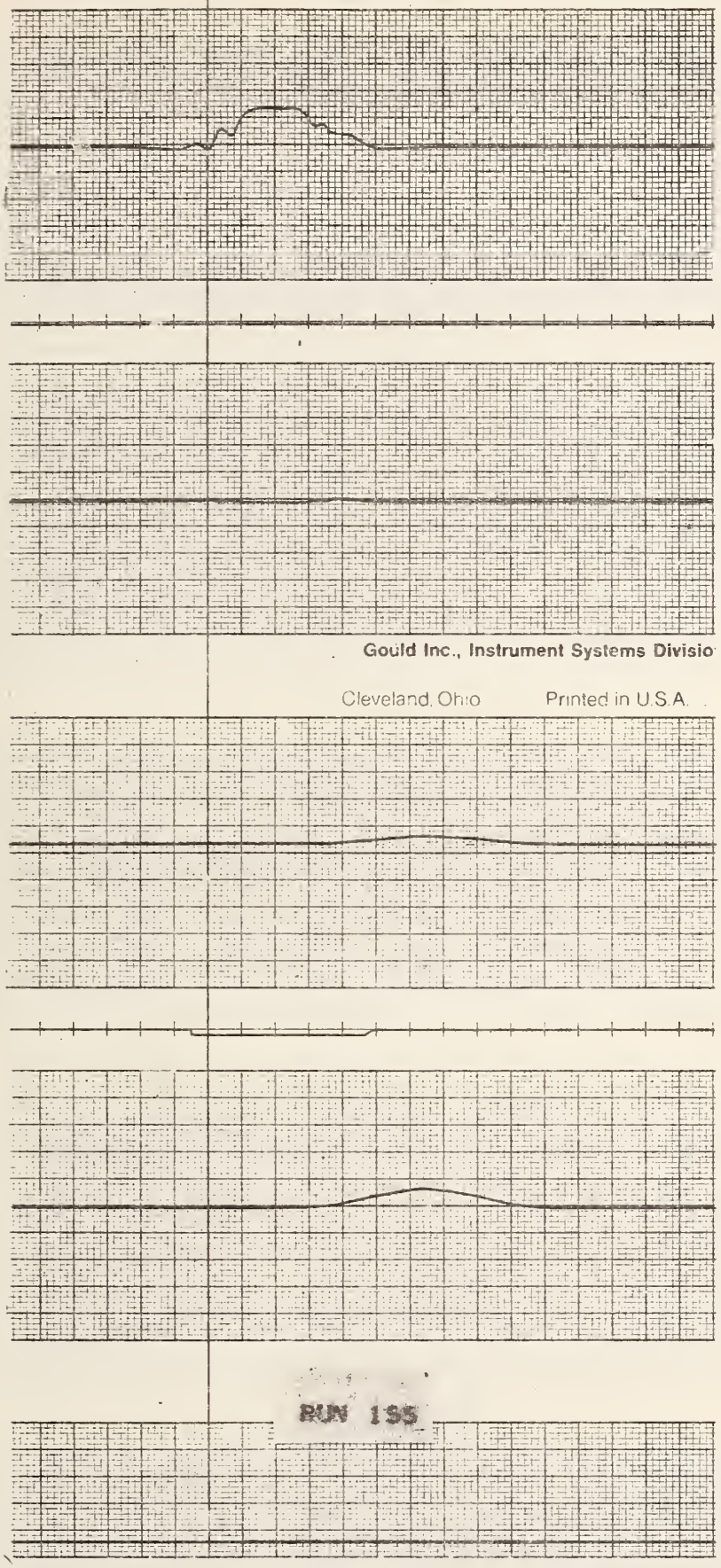

RUN 150

RUN 151


BRUSH ACCUCHART
RUN 152


RUN 153


RUN 13a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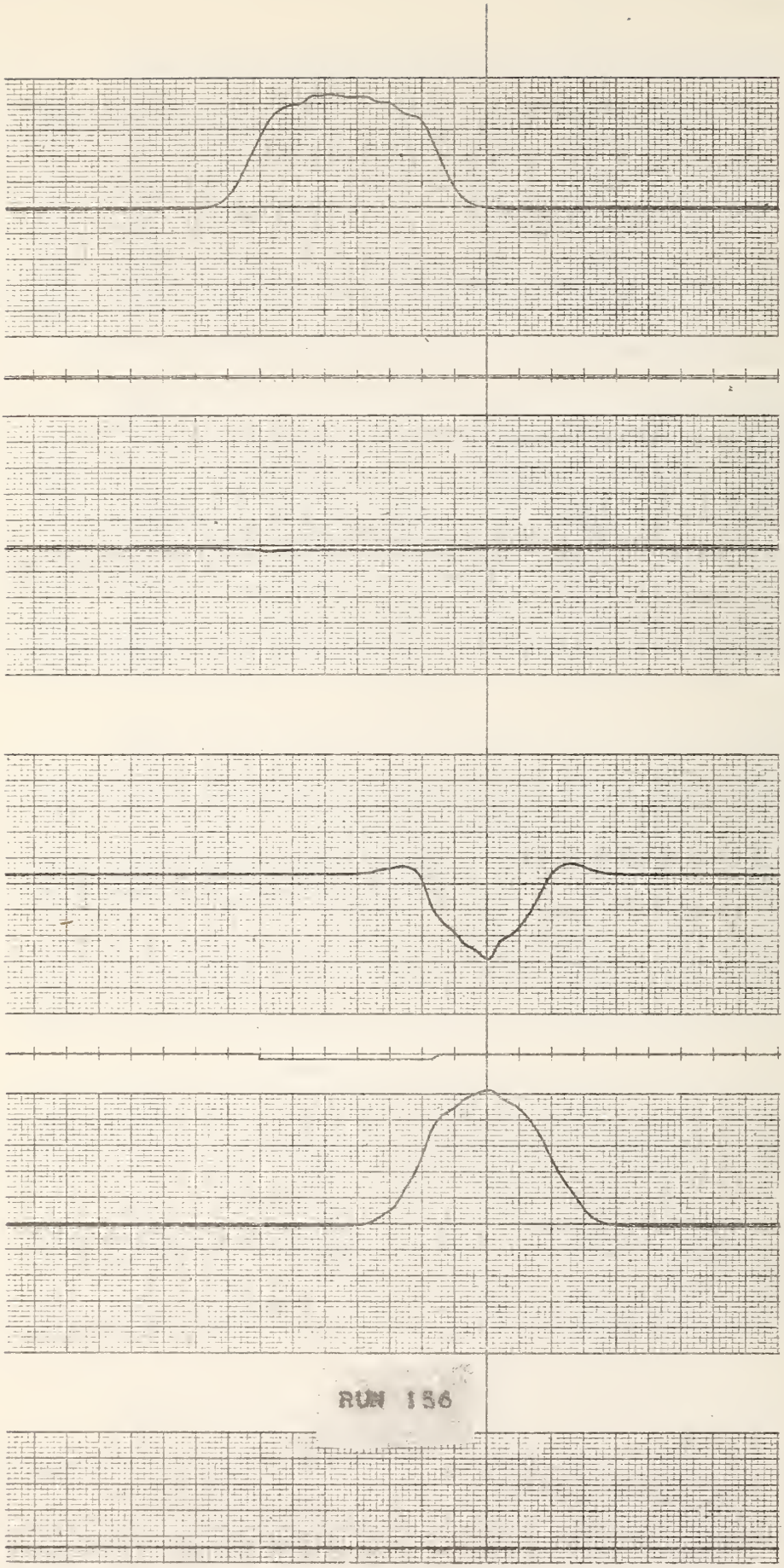
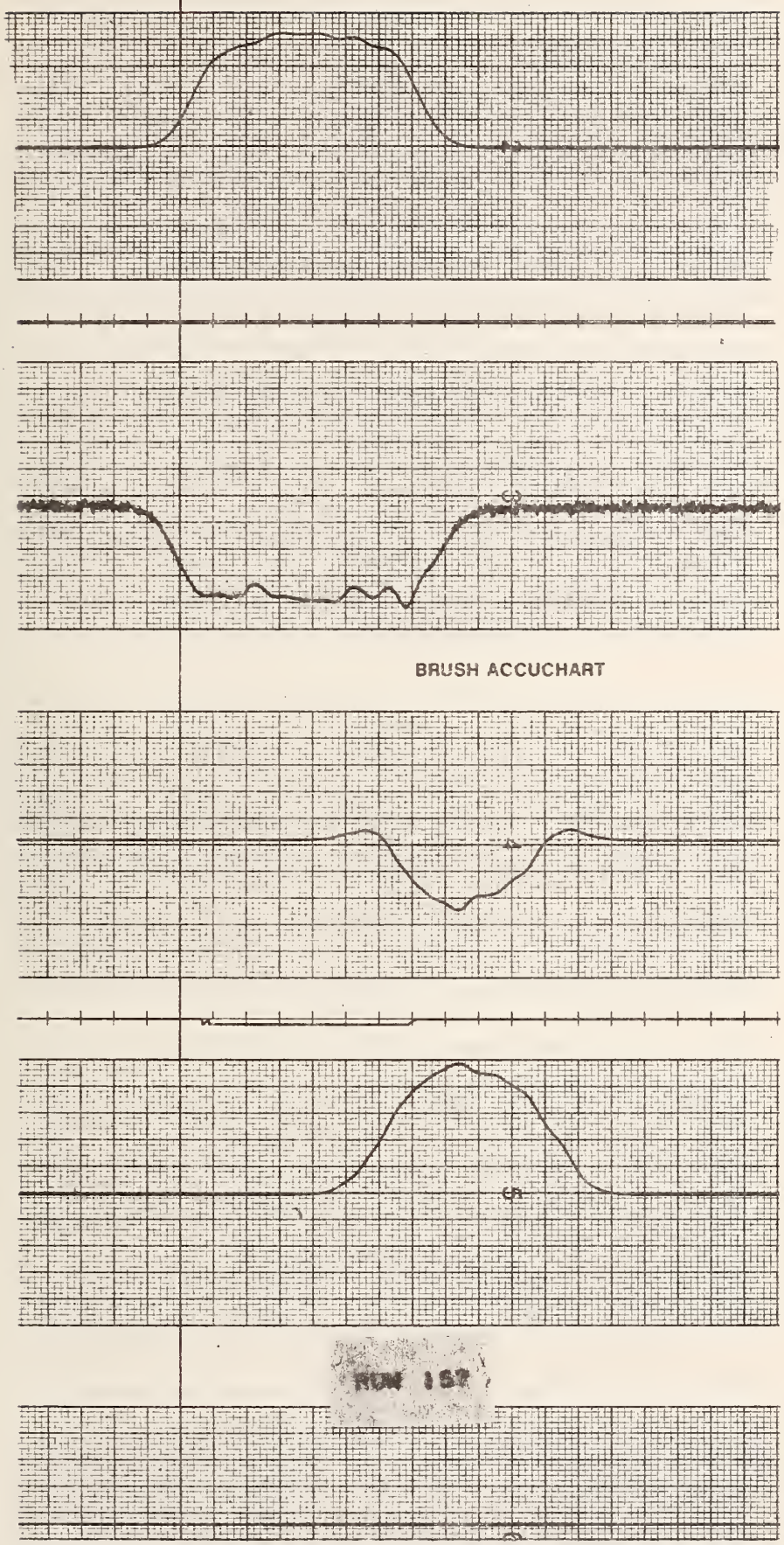
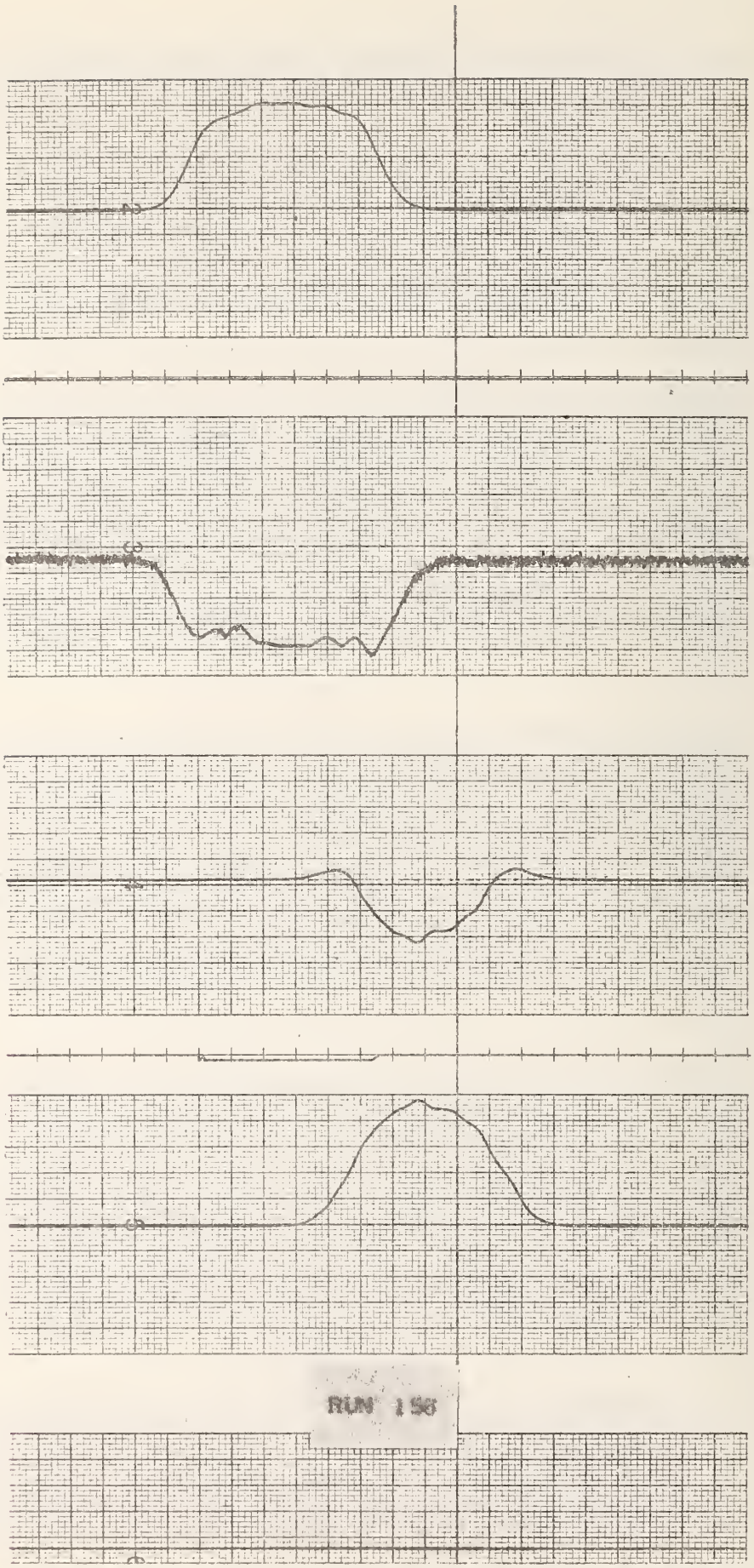
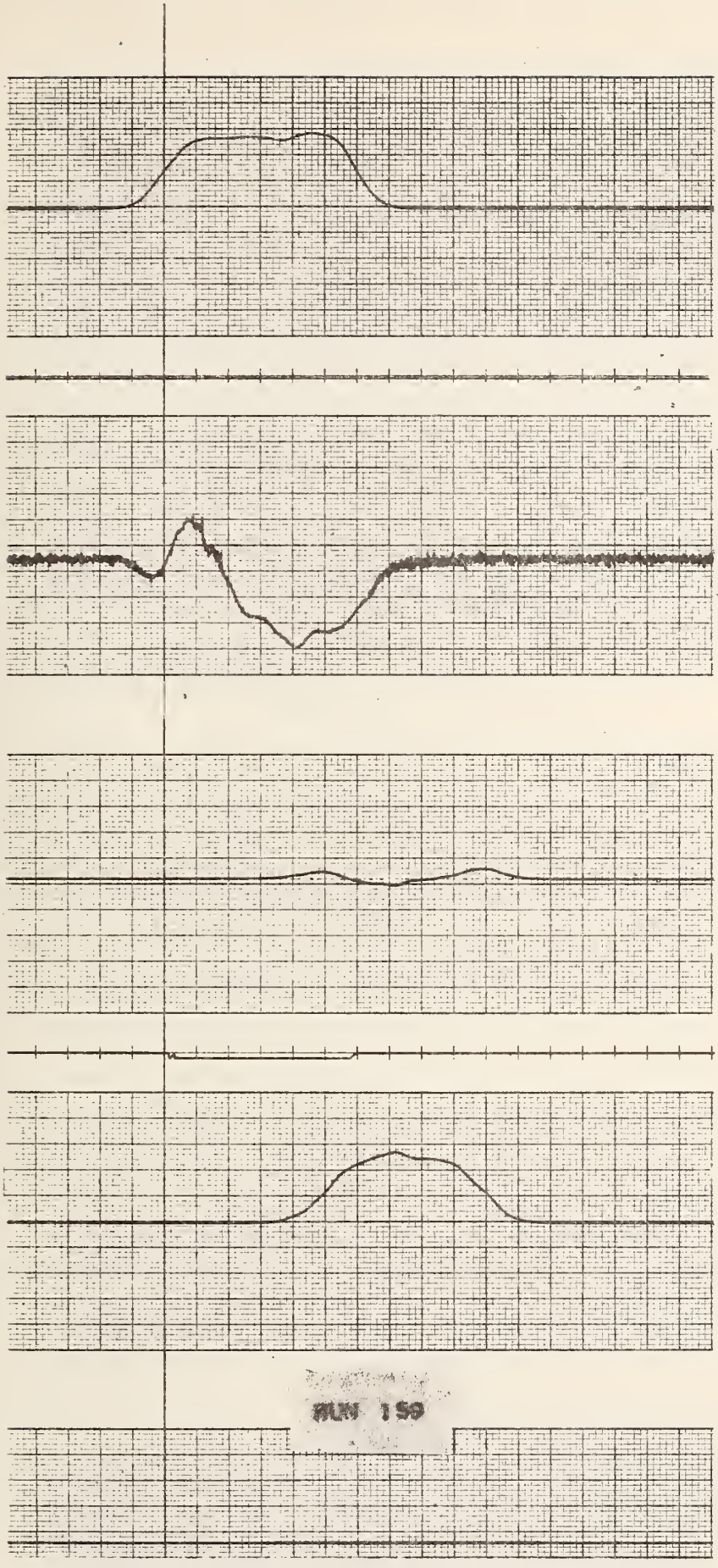
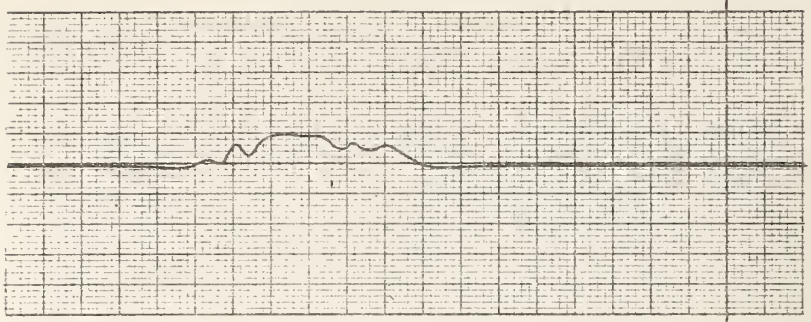
RUN 135

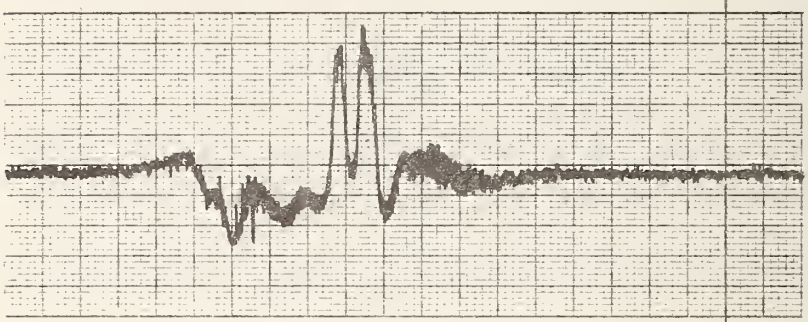

RUN 156


BRUSH ACCUCHART


RUN 156


RUN 159





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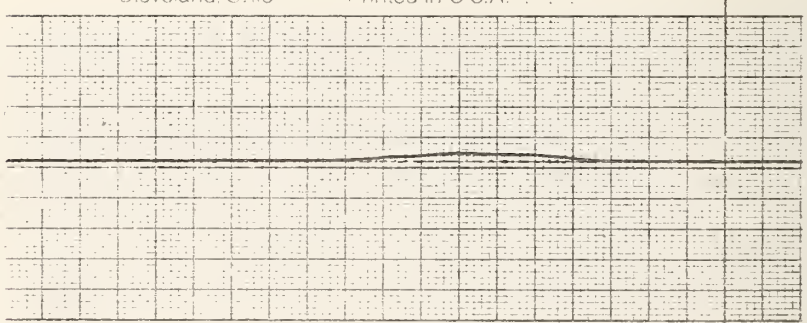

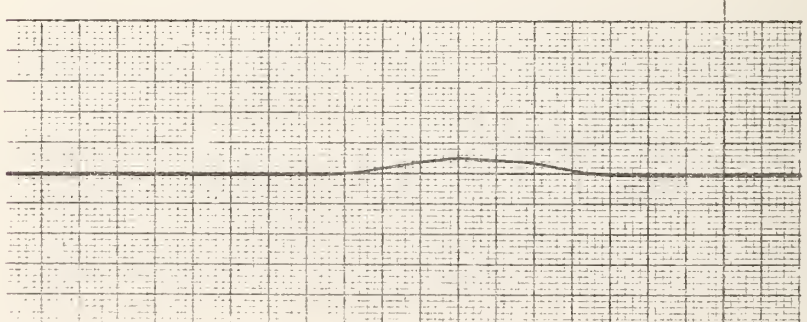

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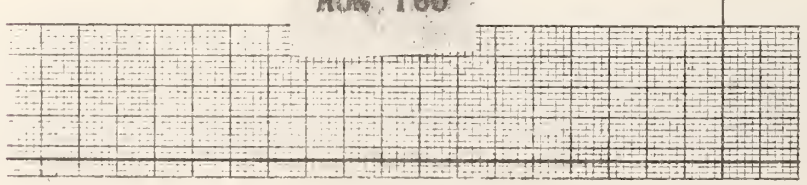
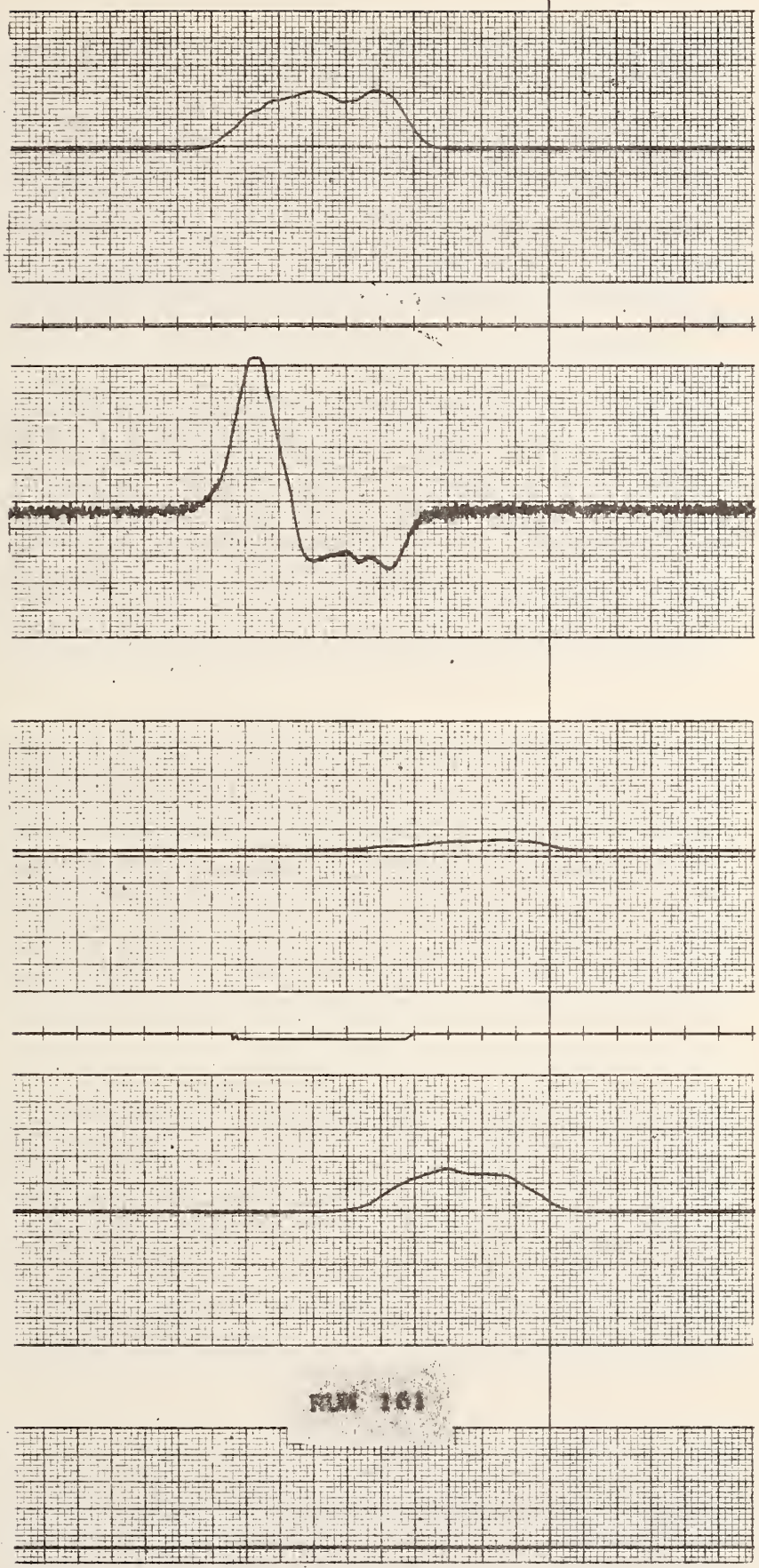
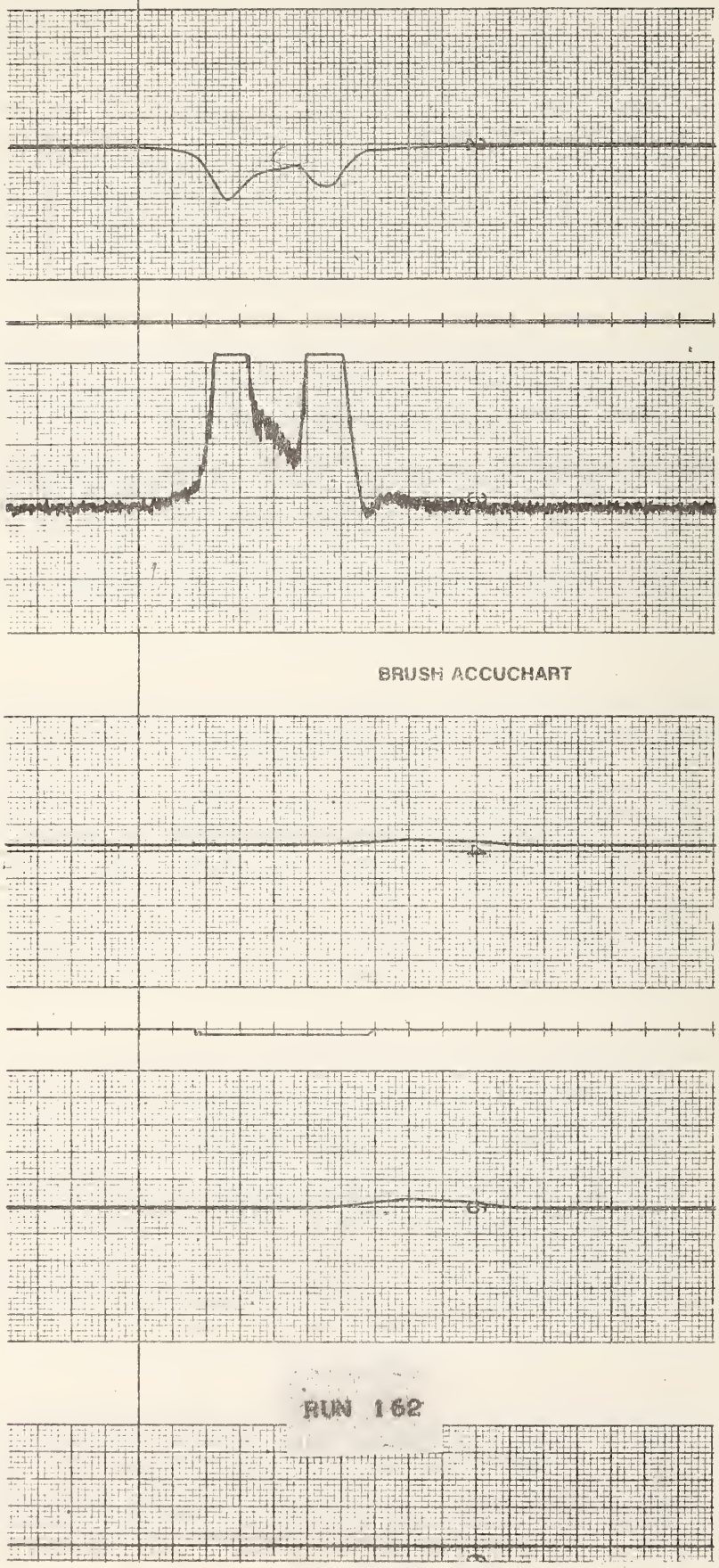
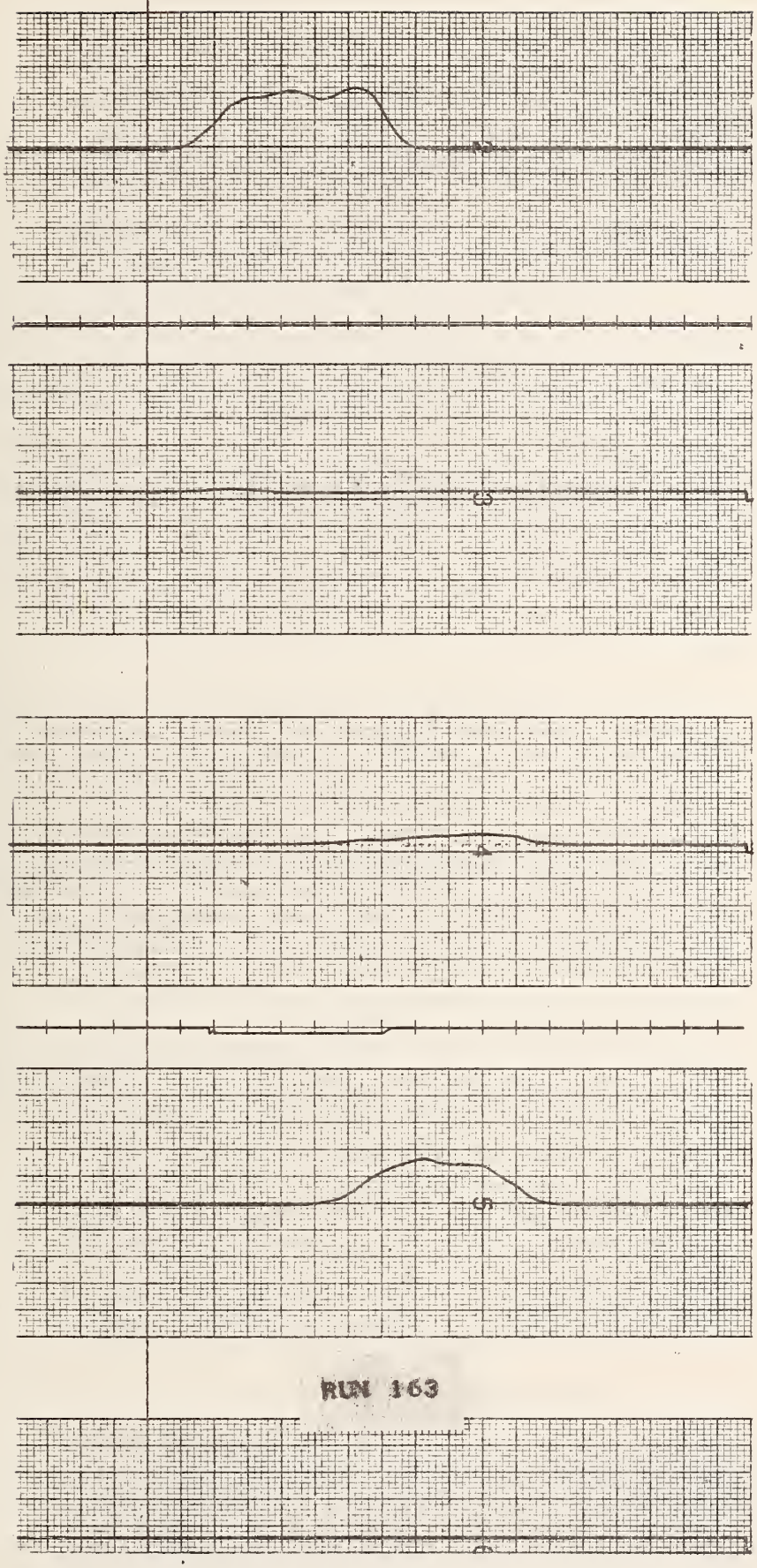
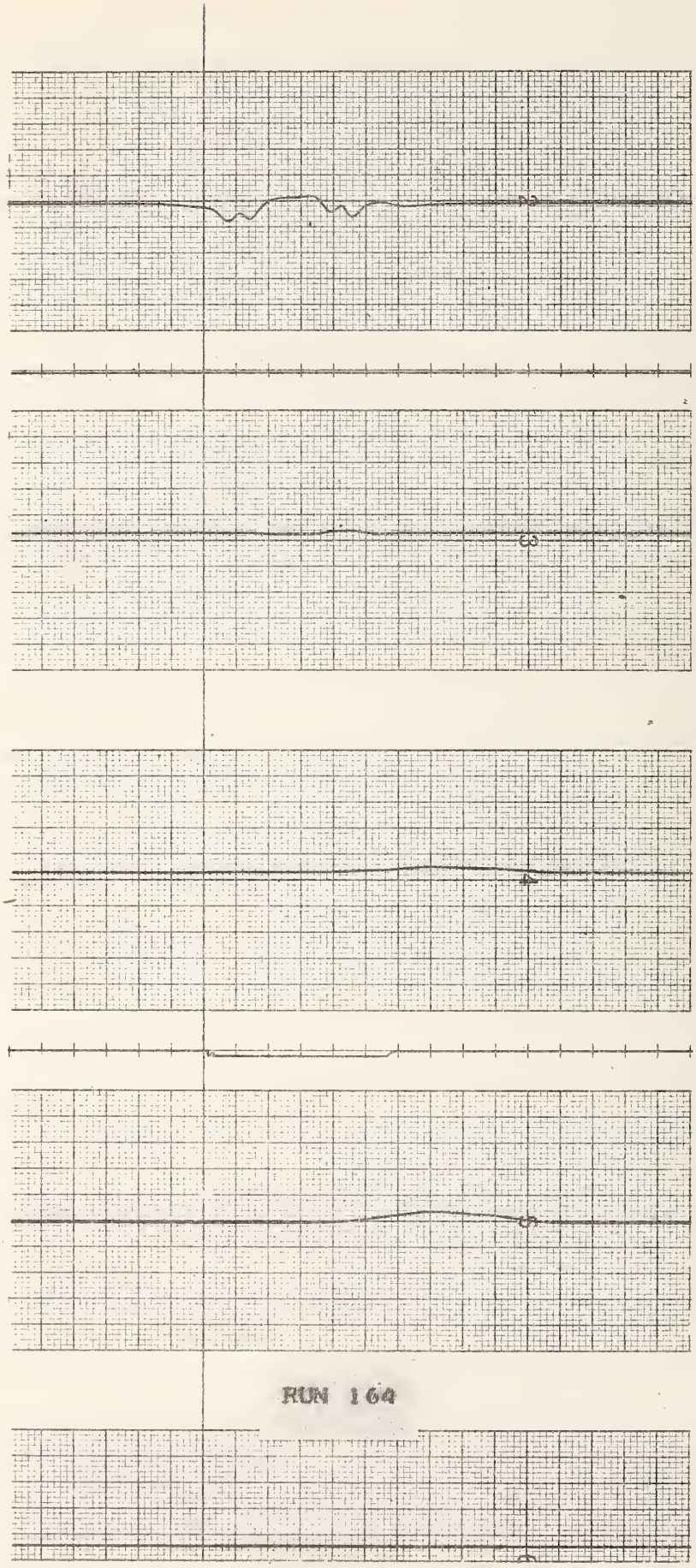



FILM 161

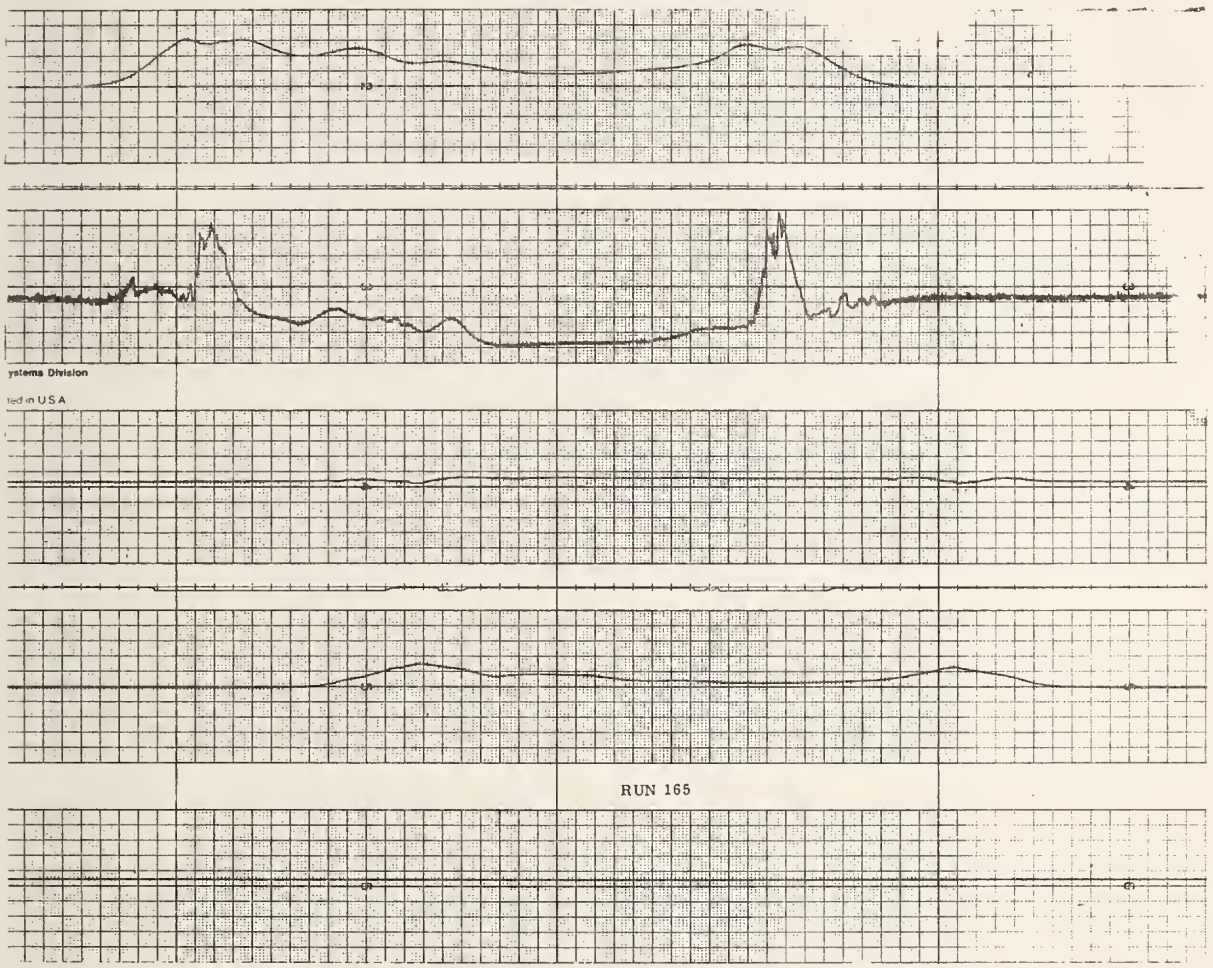

BRUSH ACCUCHART
RUN 162



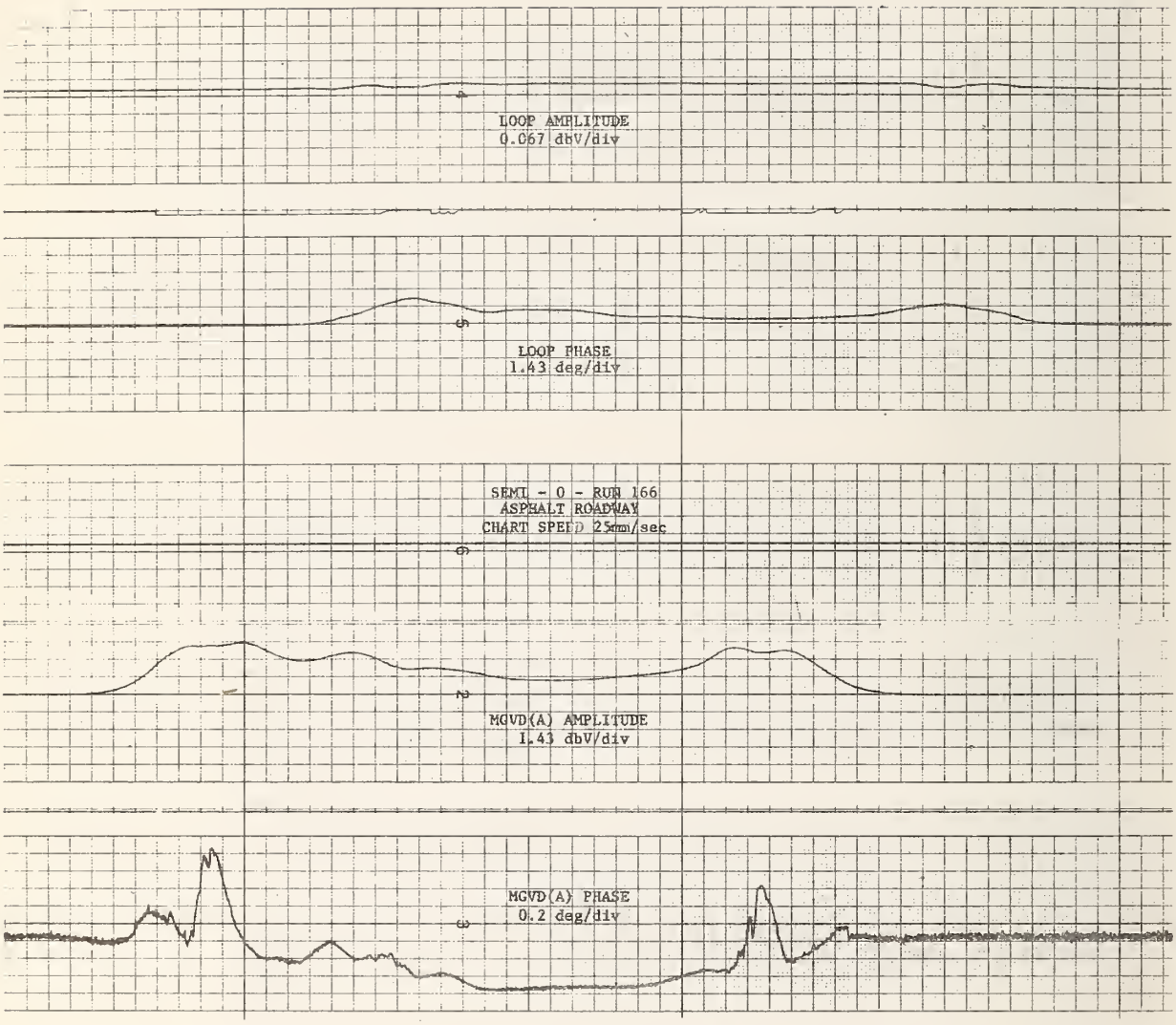
RUN 163

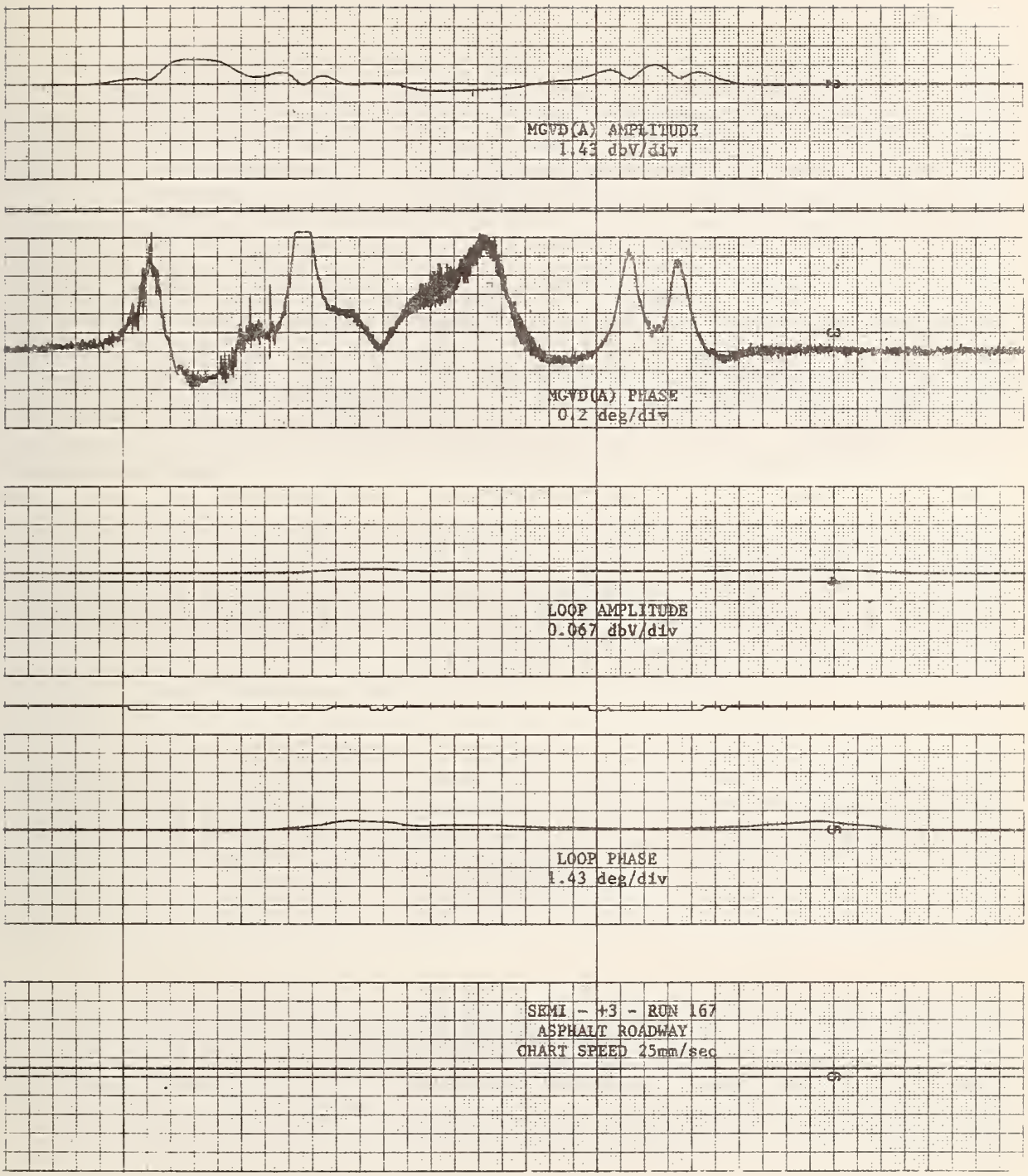


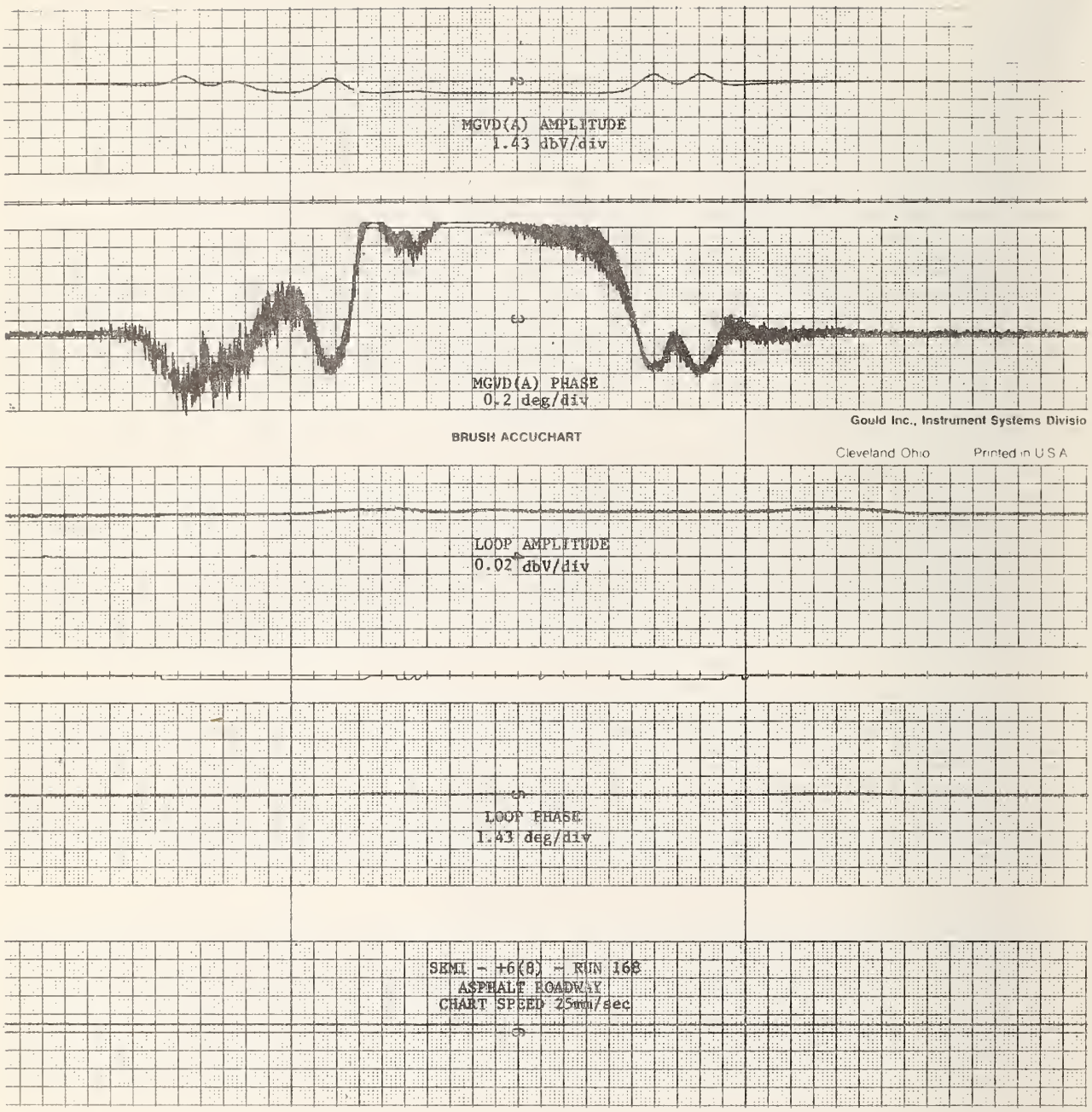
RUN 164



RUN 165


LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
SEMI - 0 - RUN 166
ASPHALT ROADWAY
CHART SPEED 25mm/sec
MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
SEMI - +3 - RUN 167
ASPHALT ROADWAY
CHART SPEED 25mm/sec


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
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BRUSH ACCUCHART
Cleveland Ohio
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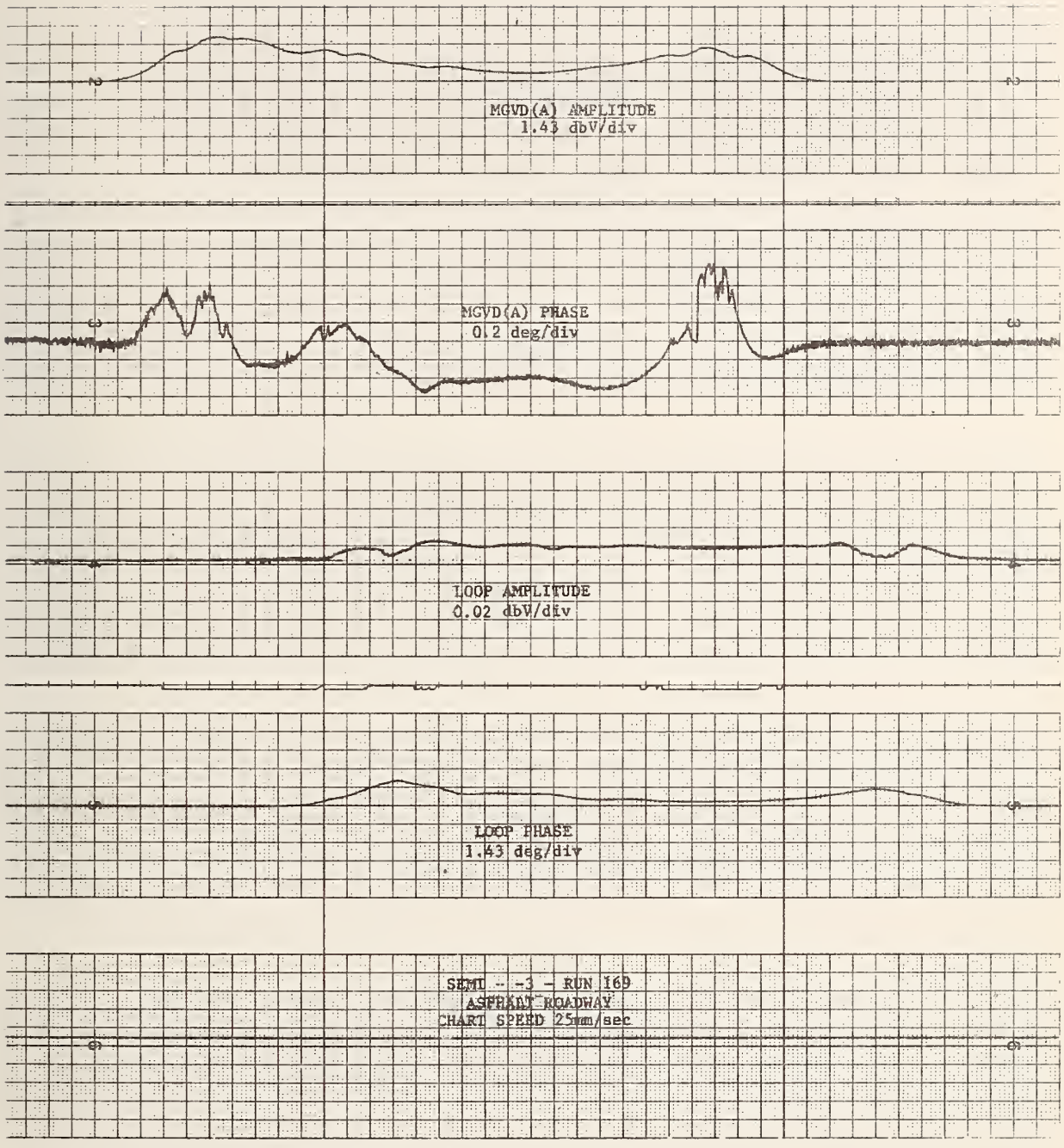
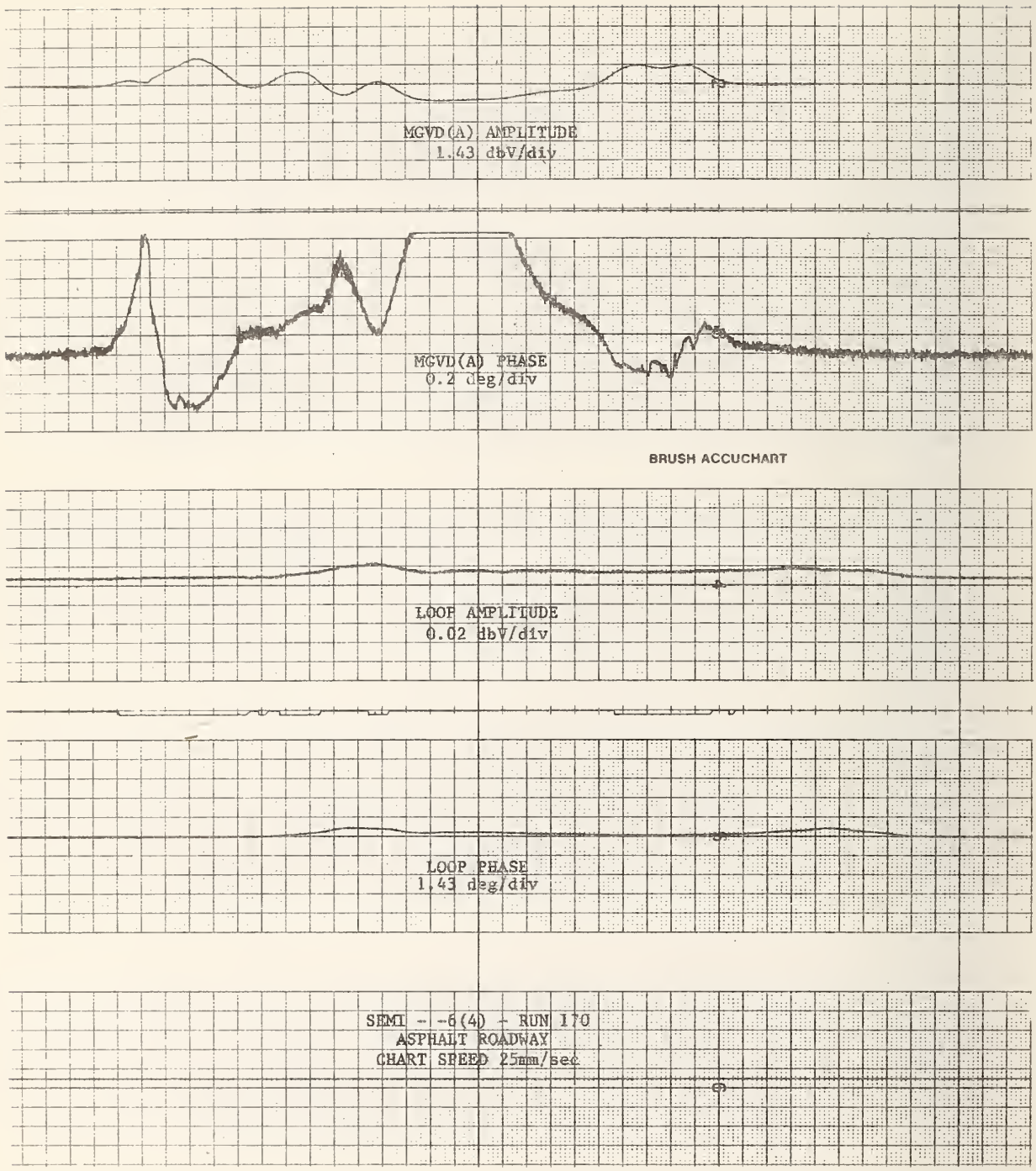
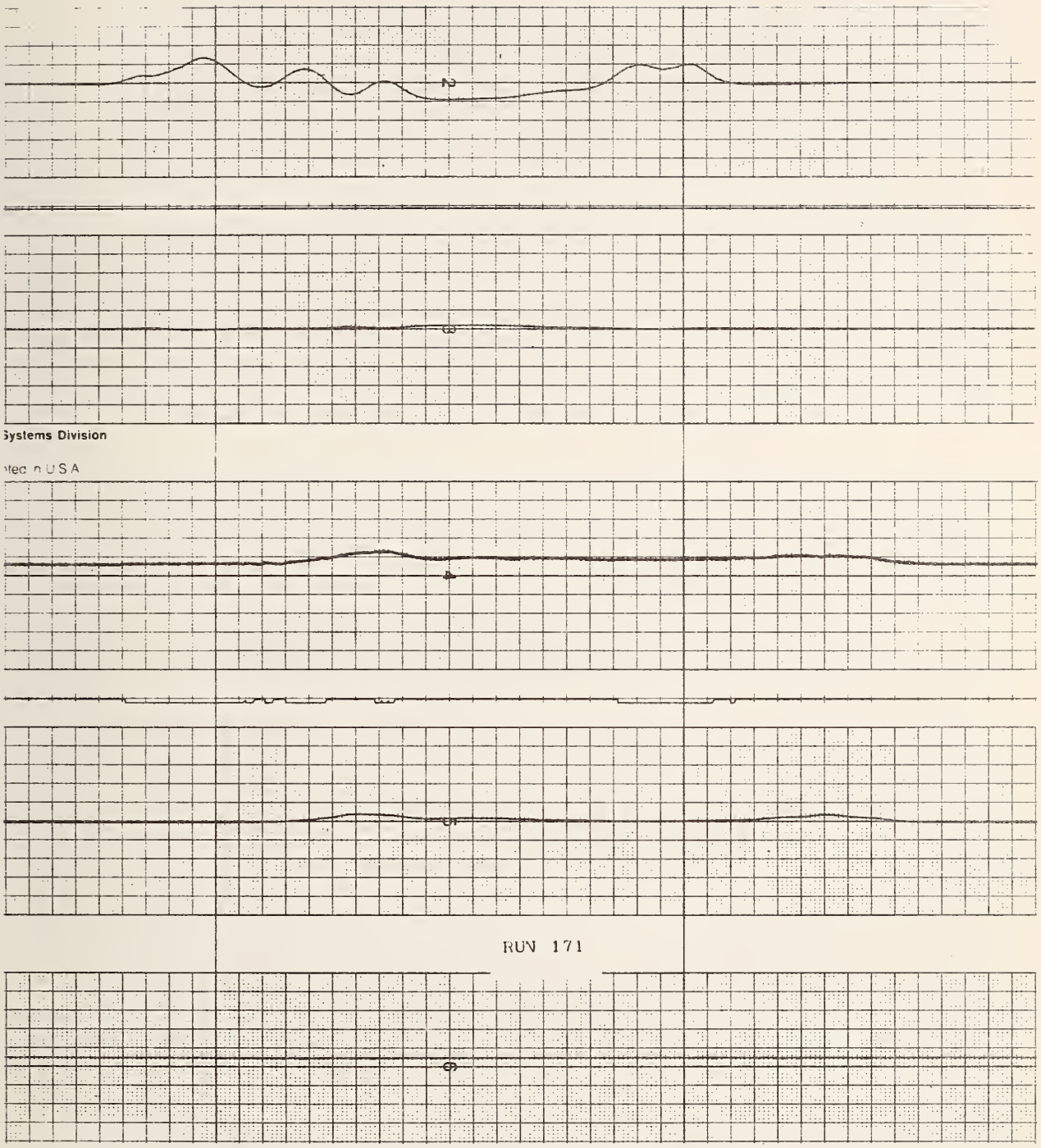
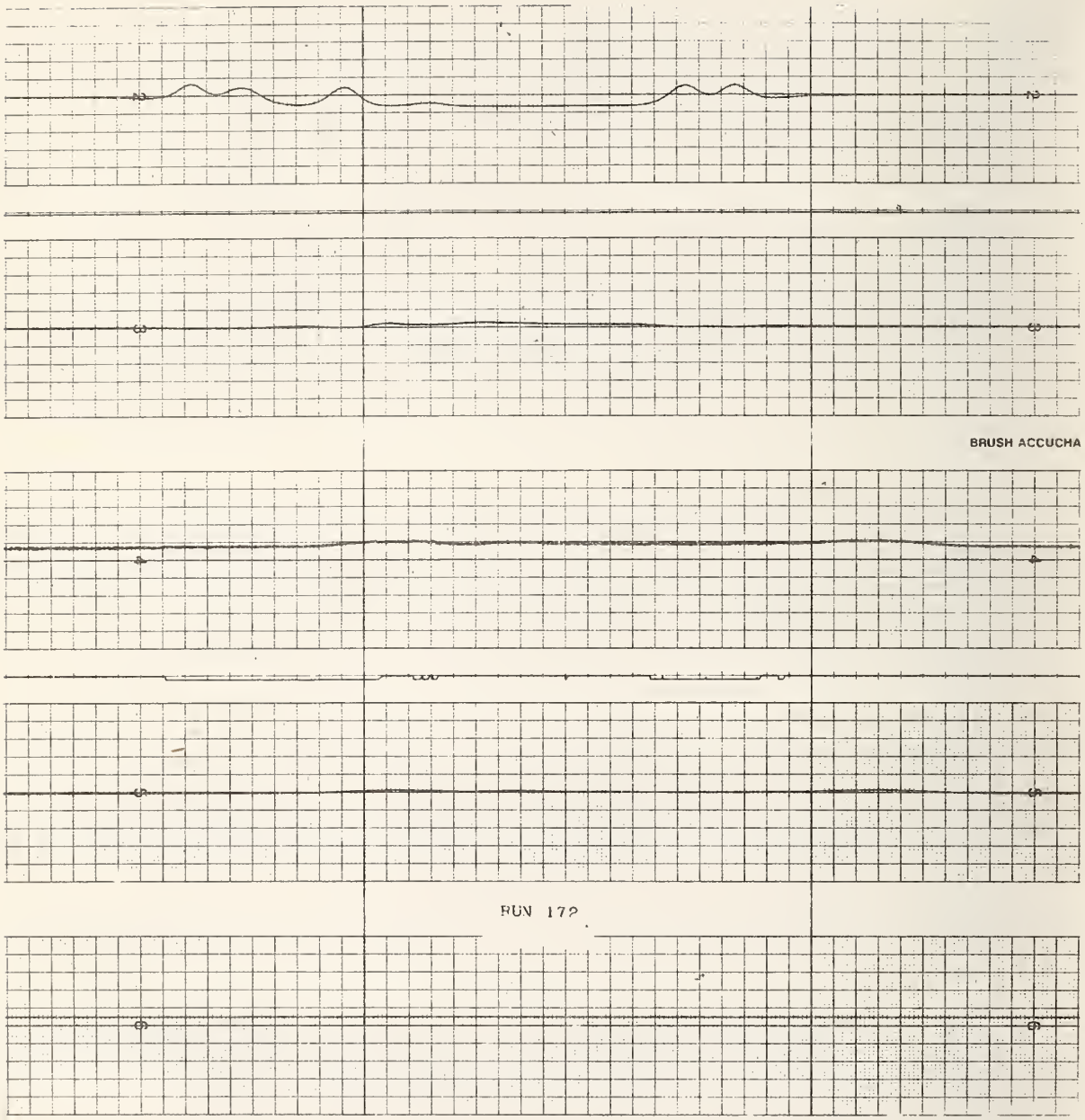
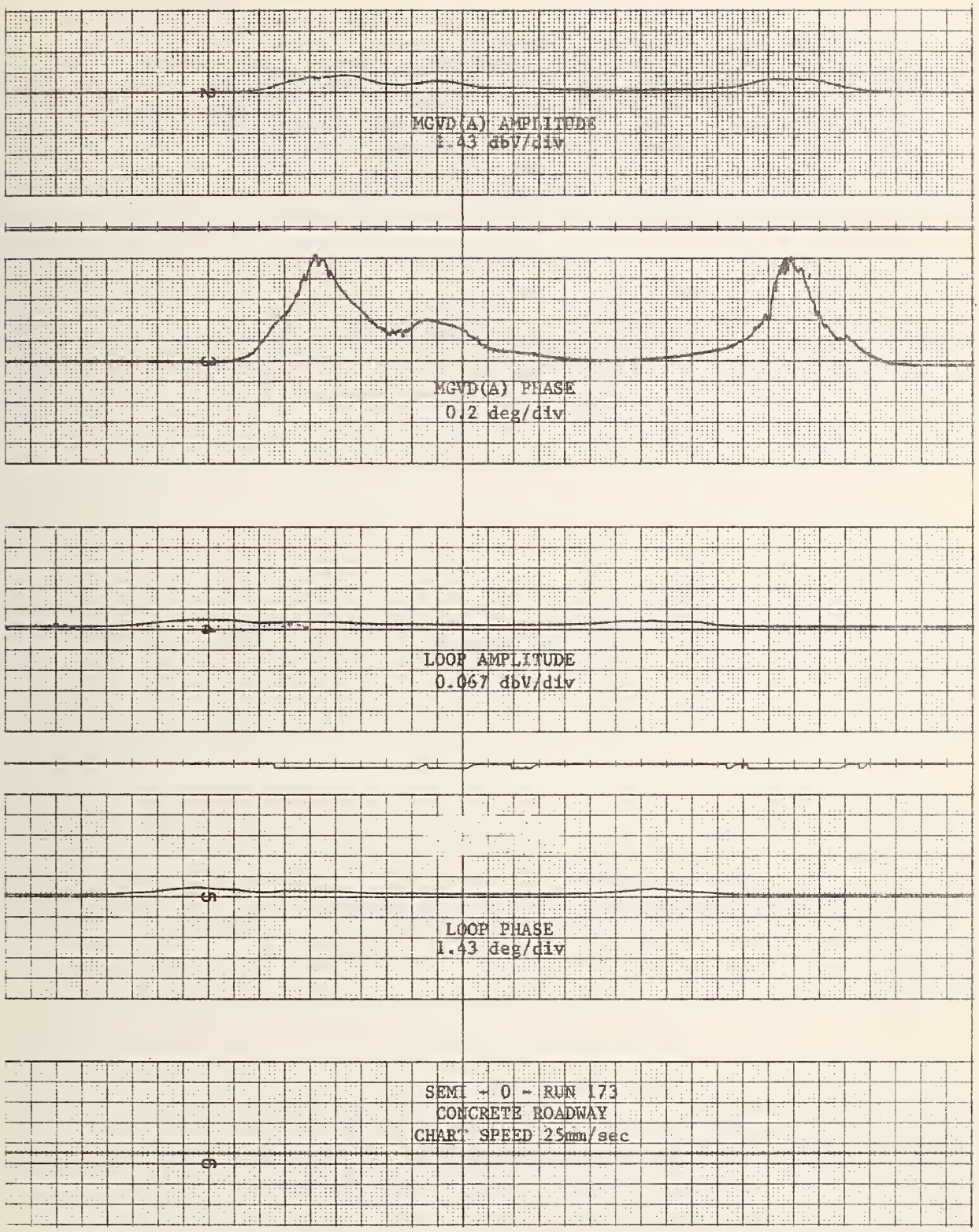
LOOP AMPLITUDE
0.02 dbV/div
LOOP PHASE
1.43 deg/div
SEMI - +6(8) - RUN 168
ASPHALT ROADWAY
CHART SPEED 25mm/sec

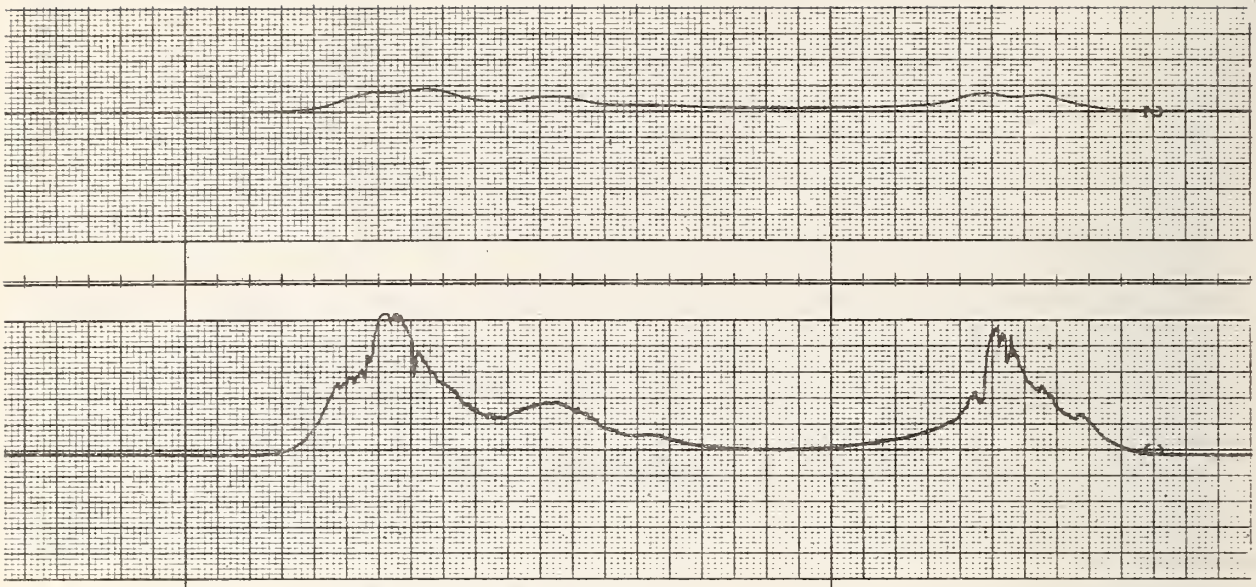

MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.02 dbV/div
LOOP PHASE
1.43 deg/div
SEMI - -3 - RUN 169
ASPHALT ROADWAY
CHART SPEED 25mm/sec


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
BRUSH ACCUCHART
LOOP AMPLITUDE
0.02 dbV/div
LOOP PHASE
1.43 deg/div
SEMI - -6(4) - RUN 170
ASPHALT ROADWAY
CHART SPEED 25mm/sec


Systems Division
RUN 171


BRUSH ACCUCHA
RUN 172


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.067 dbV/div
LOOP PHASE
1.43 deg/div
SEMI - 0 - RUN 173
CONCRETE ROADWAY
CHART SPEED 25mm/sec



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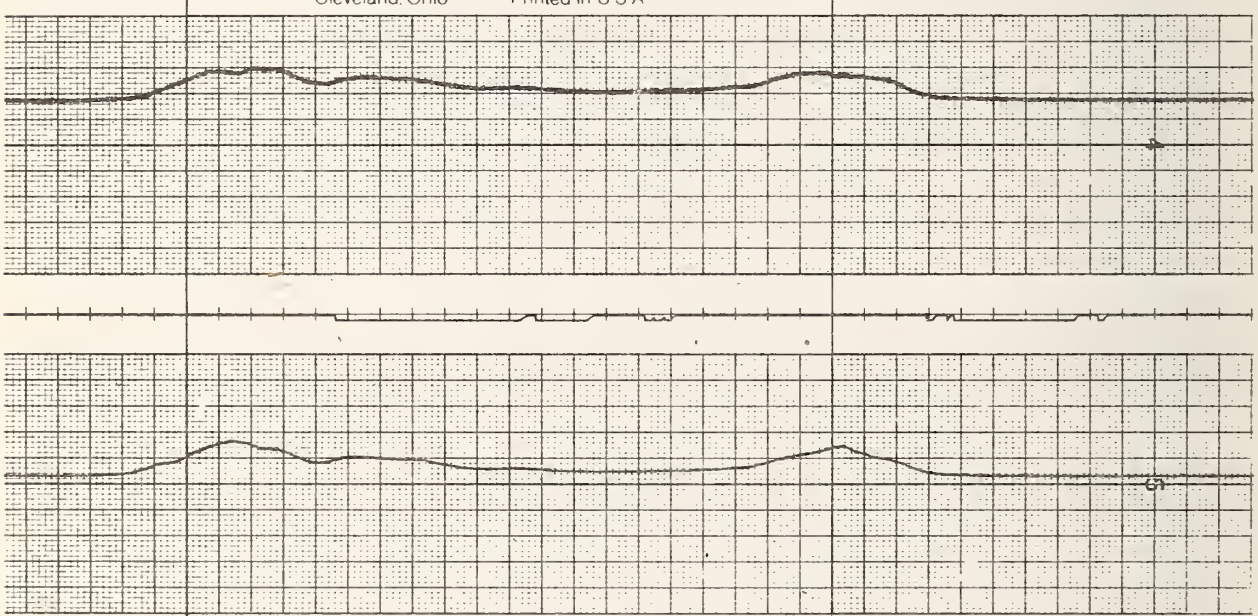
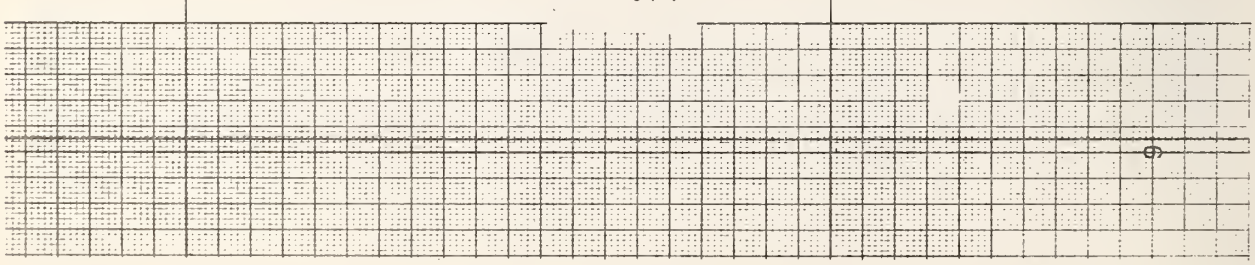
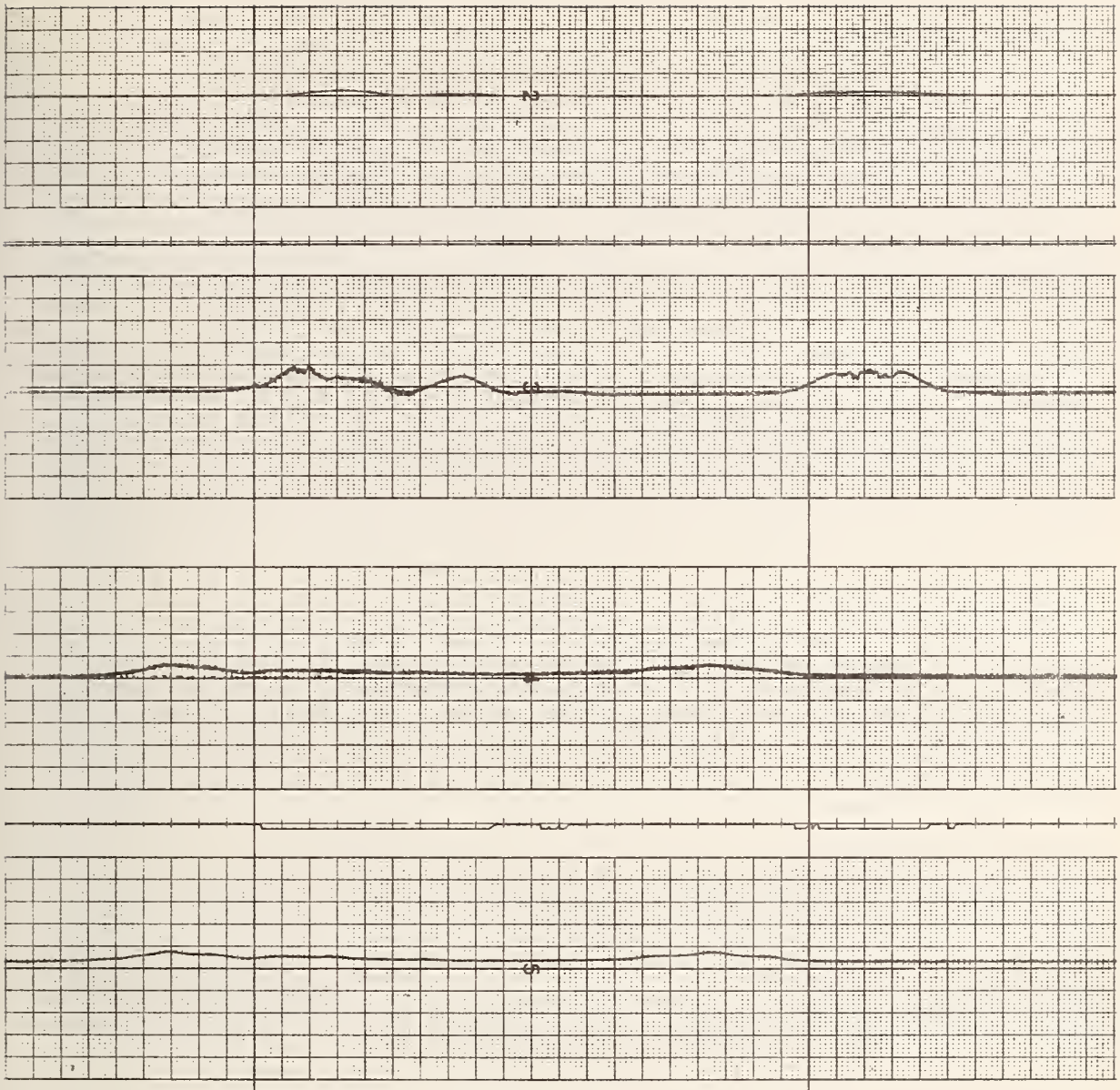
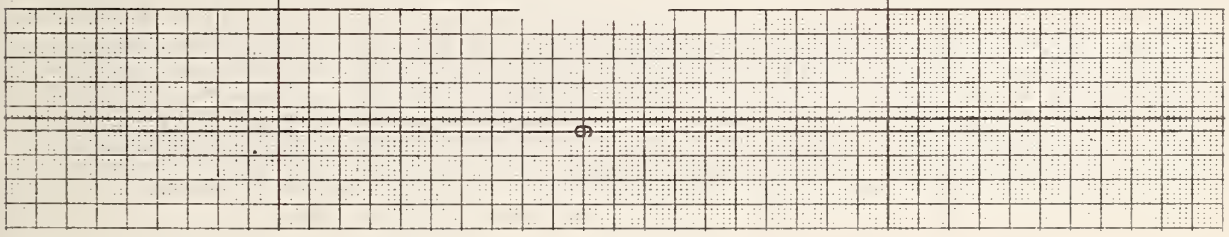


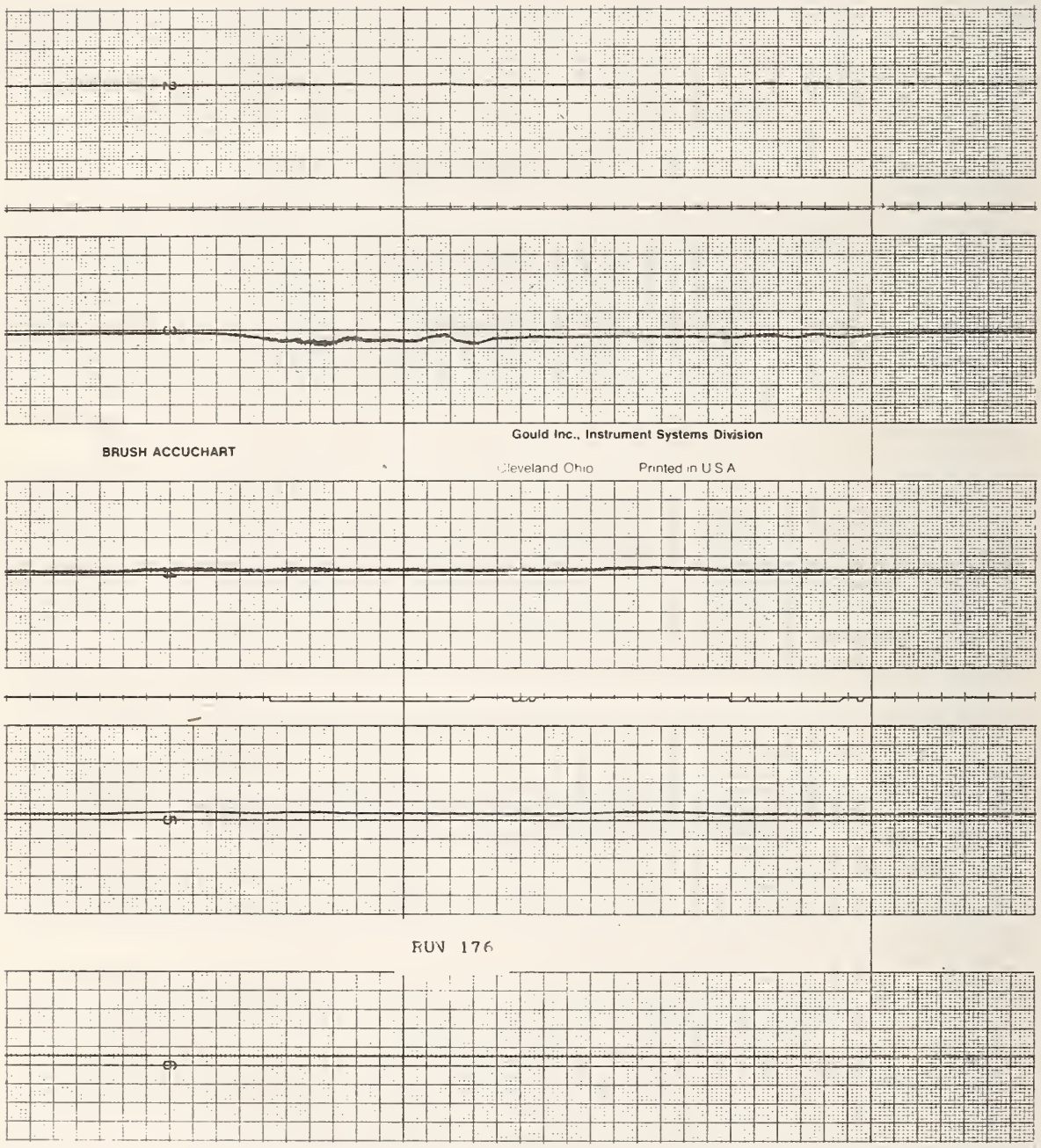
RUN 174





RUN 175

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BRUSH ACCUCHART
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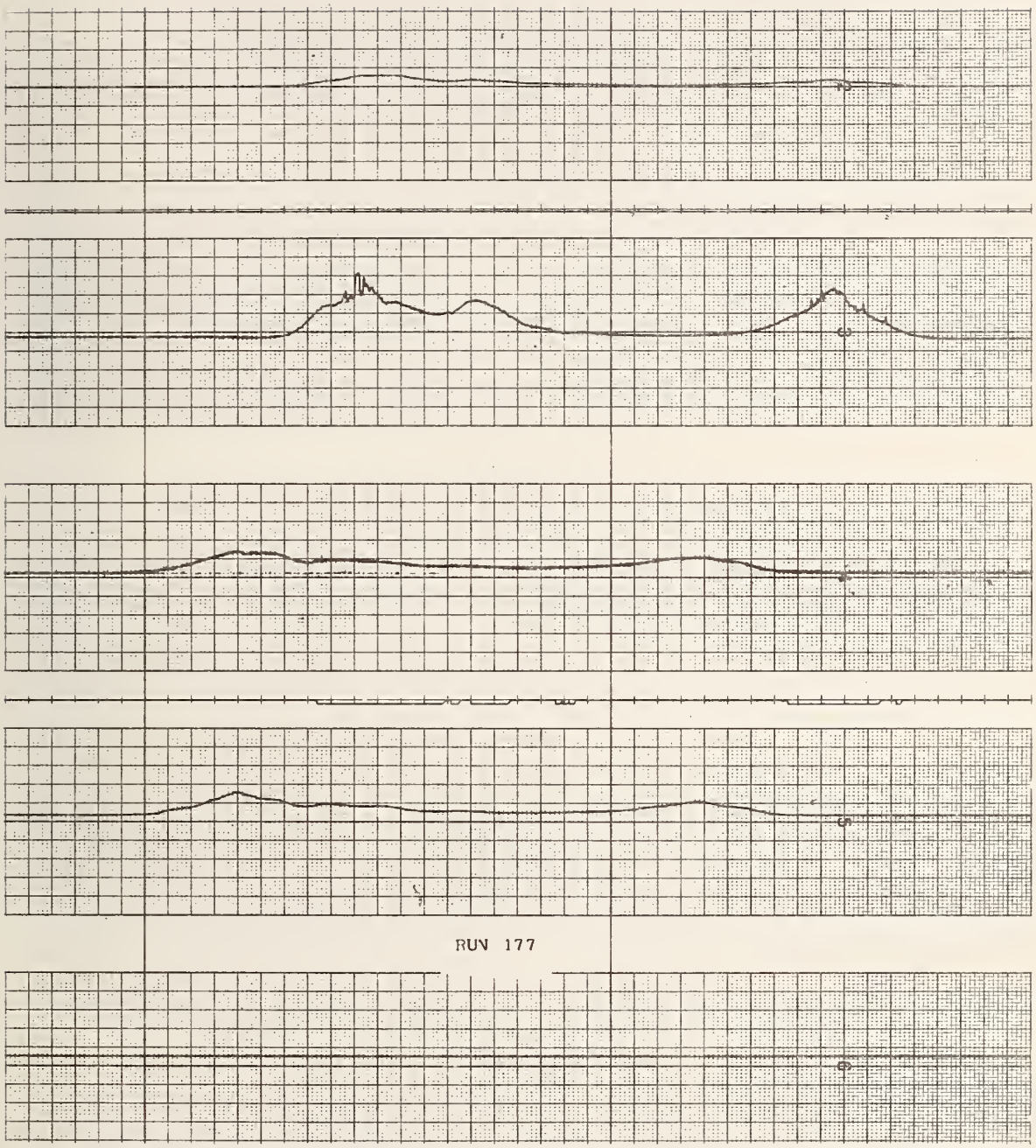
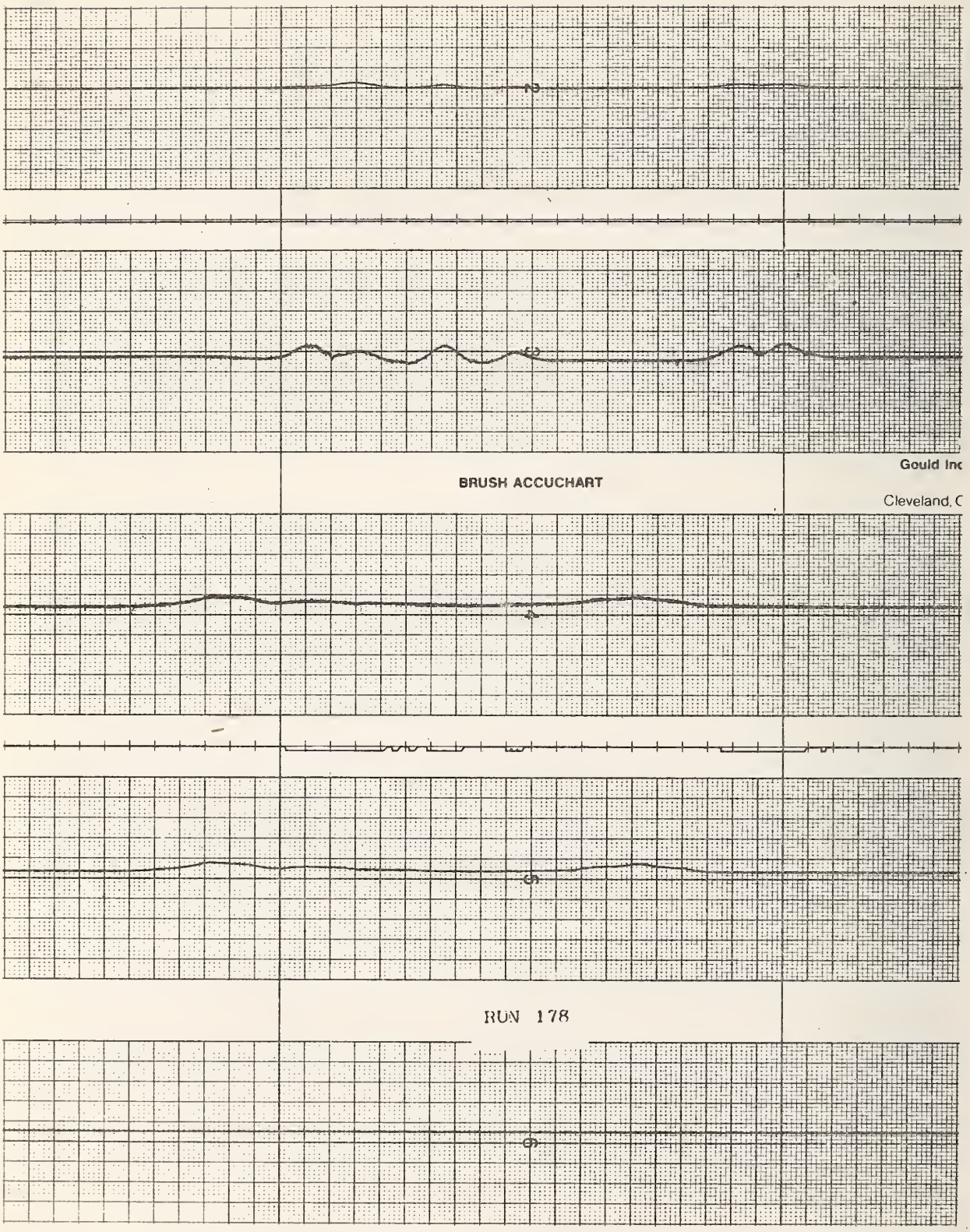
RUN 176



RUN 177


Gould Inc
BRUSH ACCUCHART
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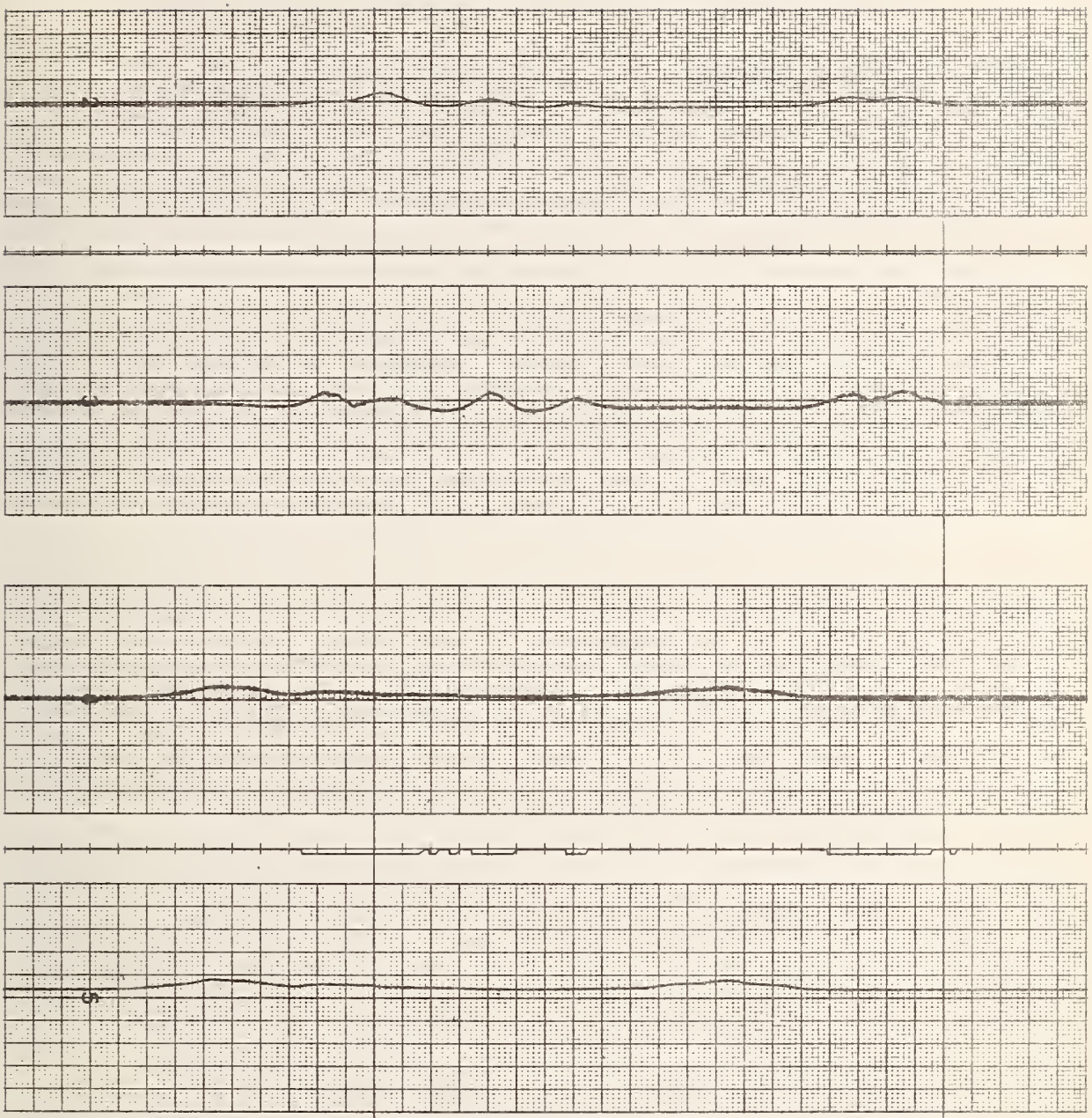
RUN 178



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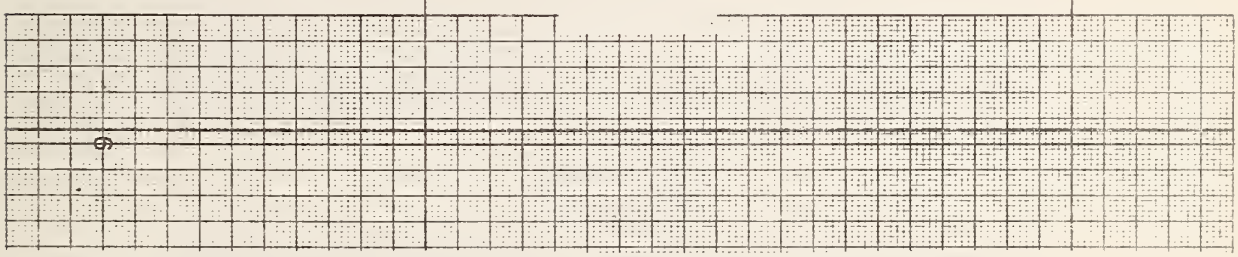

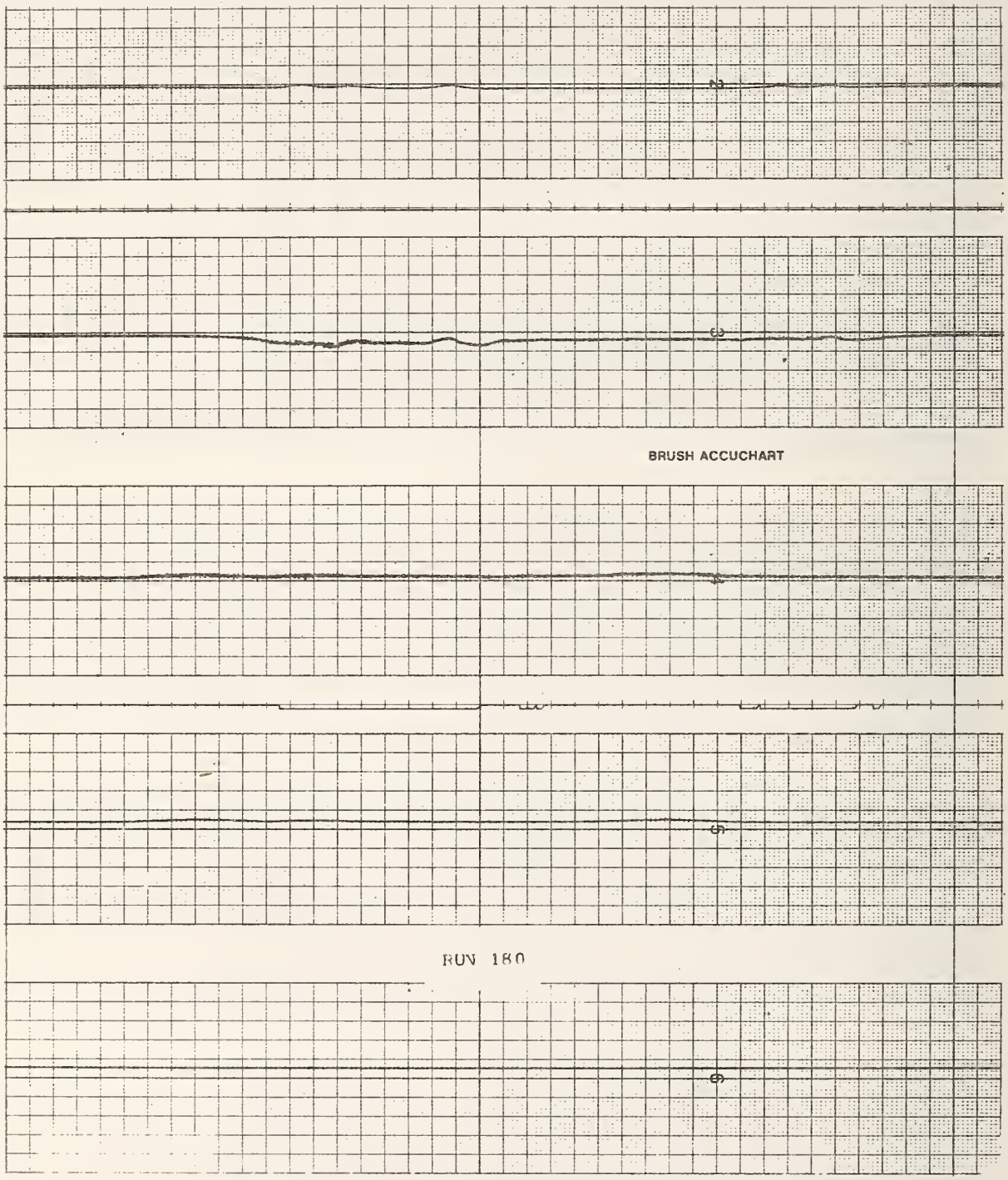
BRUSH ACCUCHART
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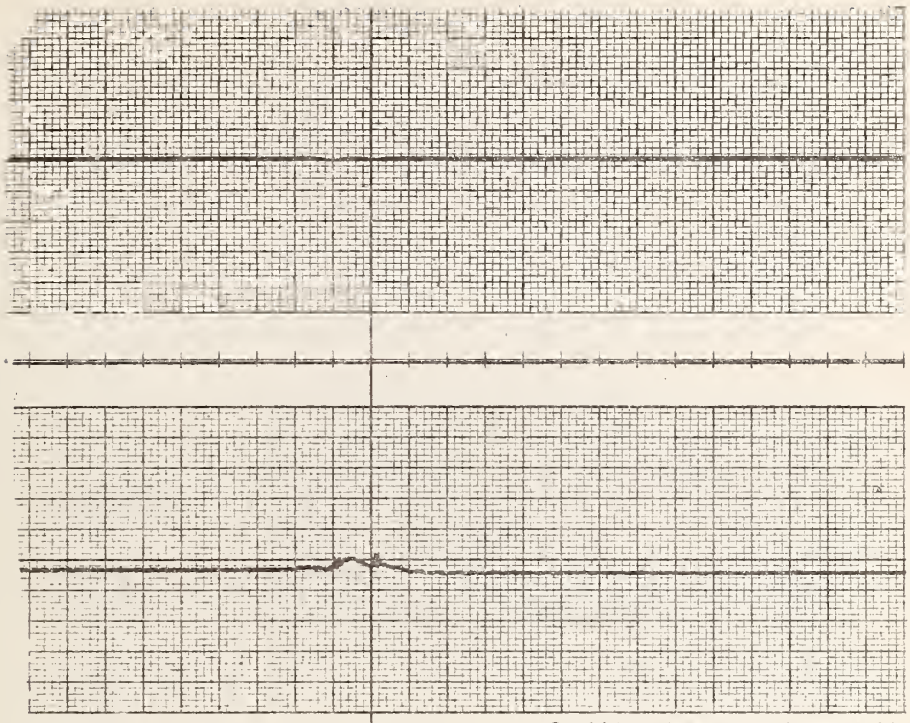

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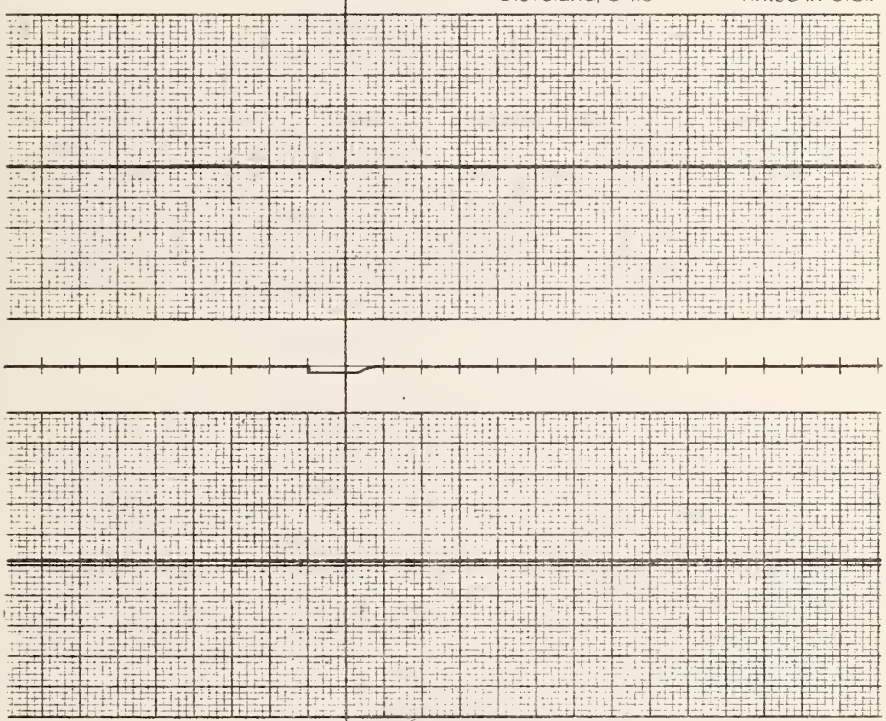

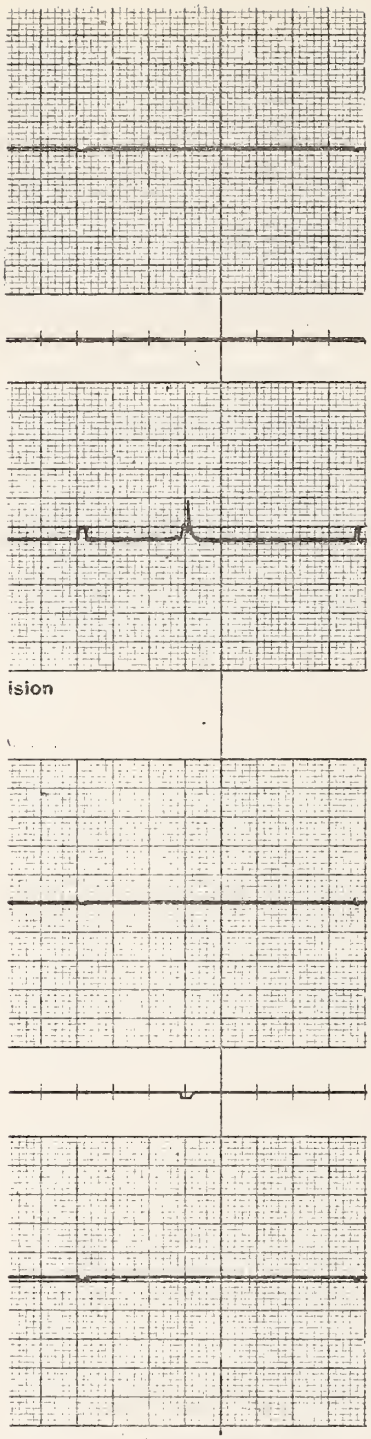

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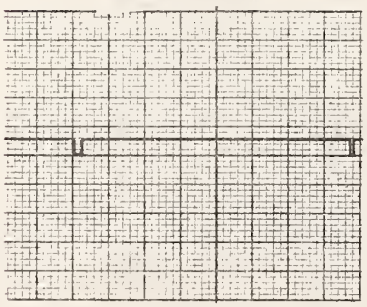
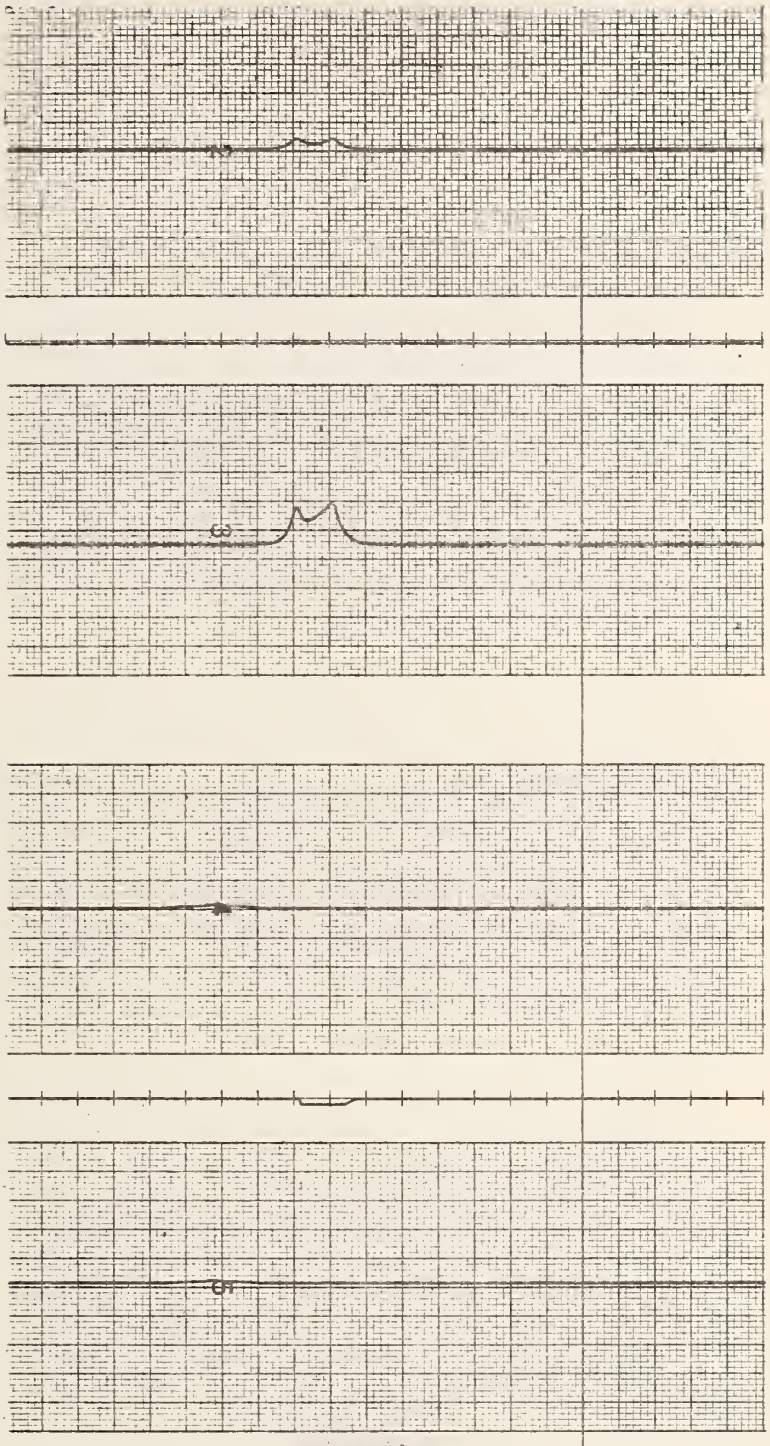
RUN 182





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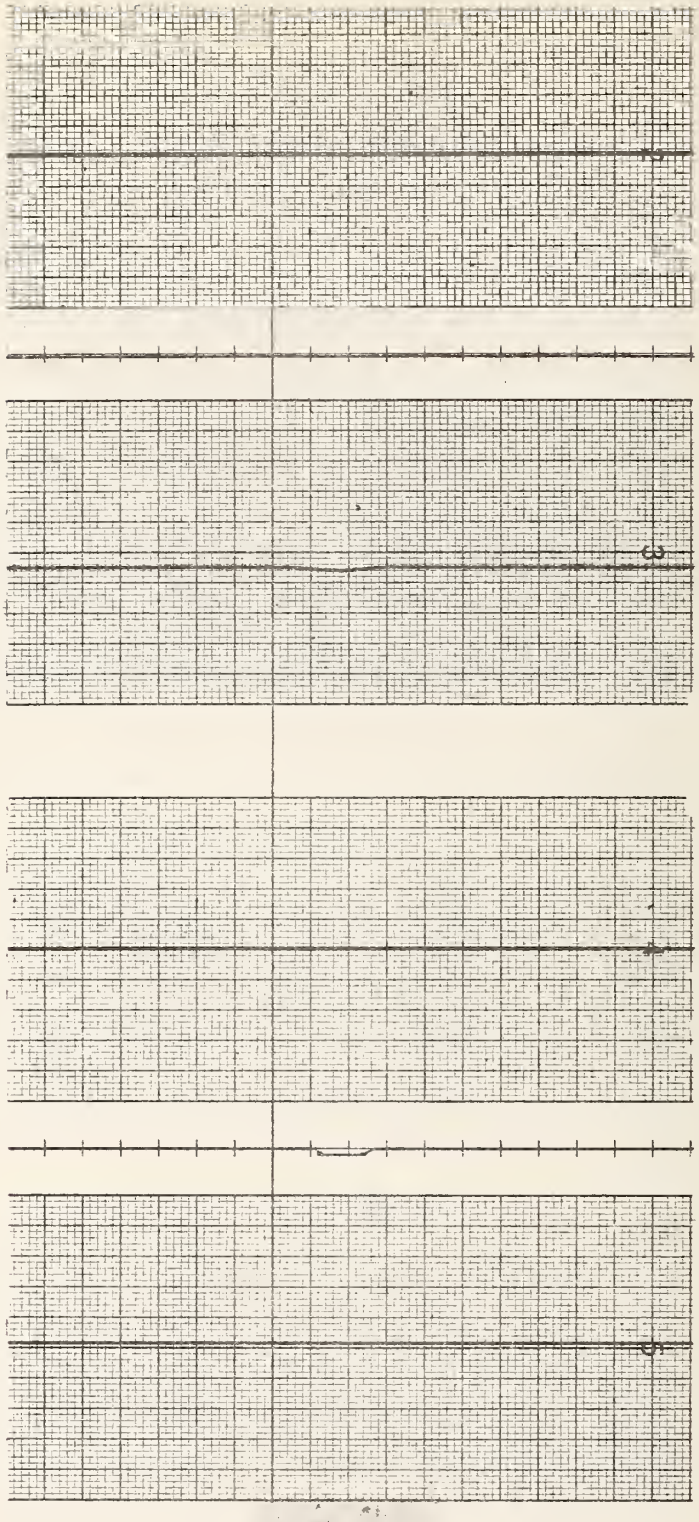

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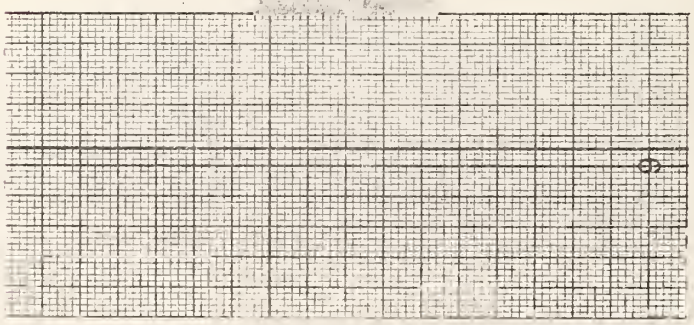

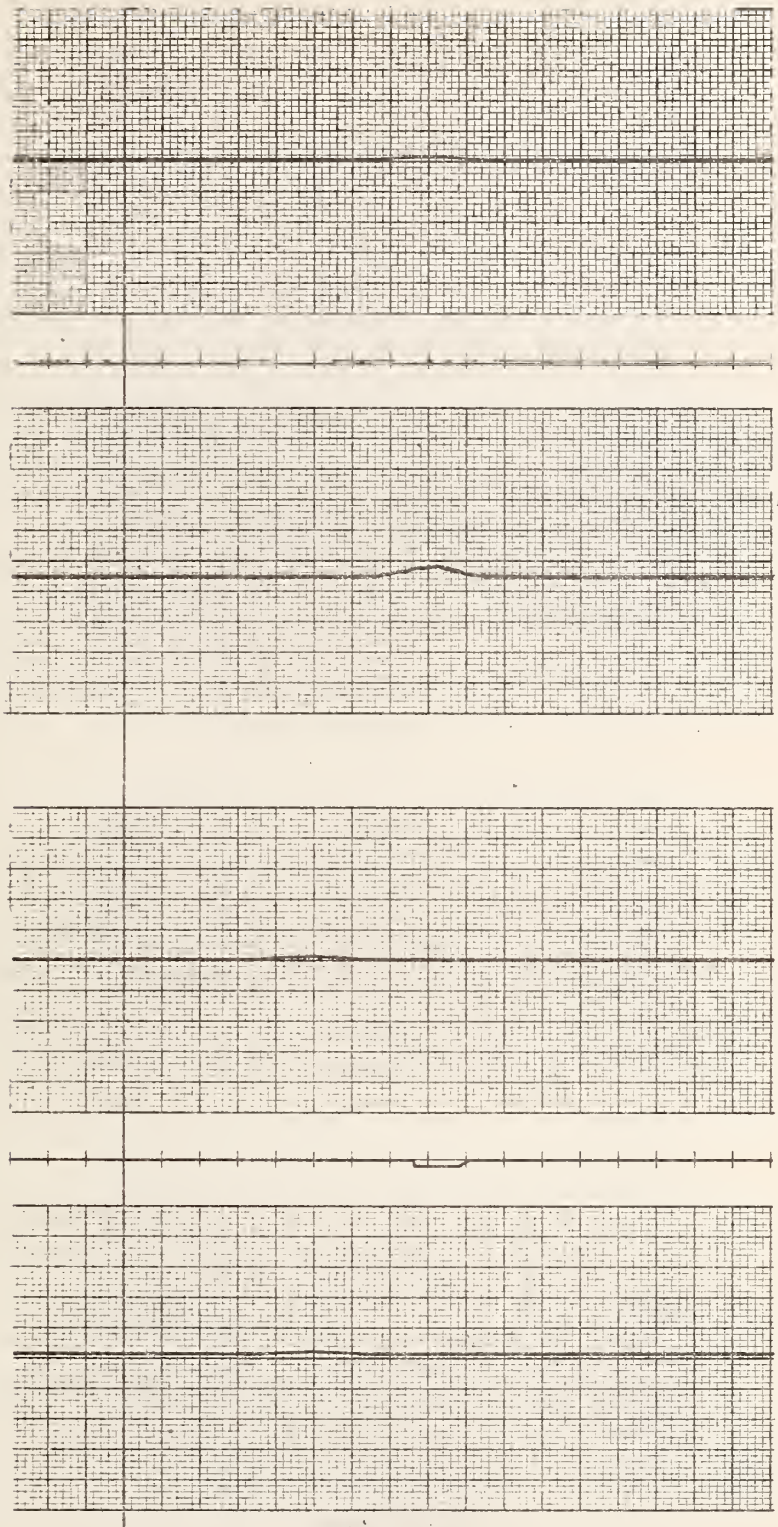

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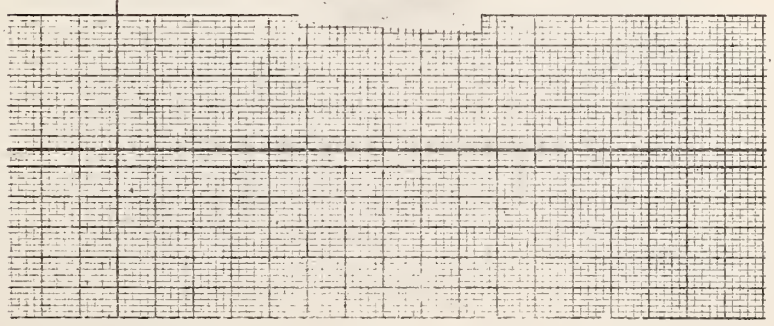
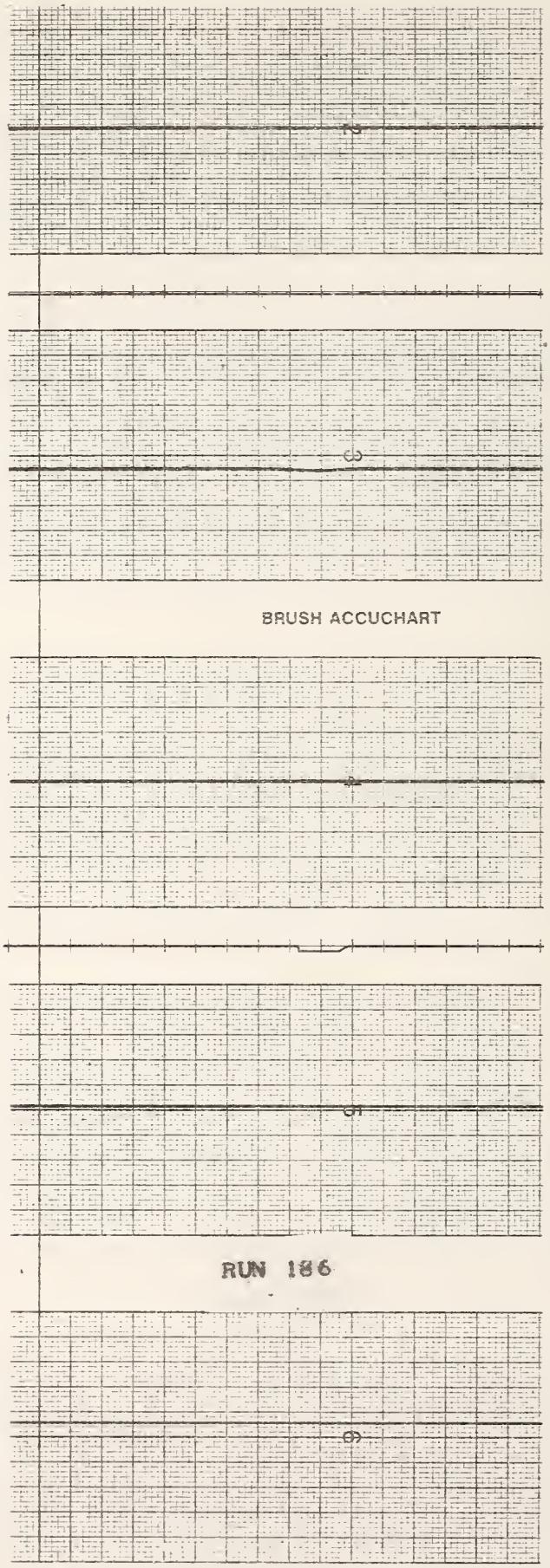
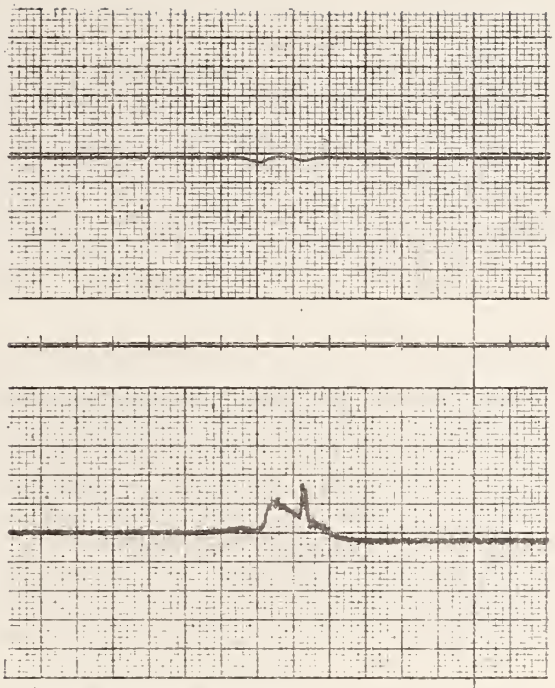



BRUSH ACCUCHART
RUN 186



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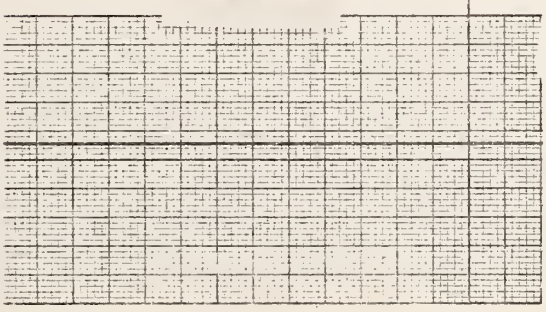
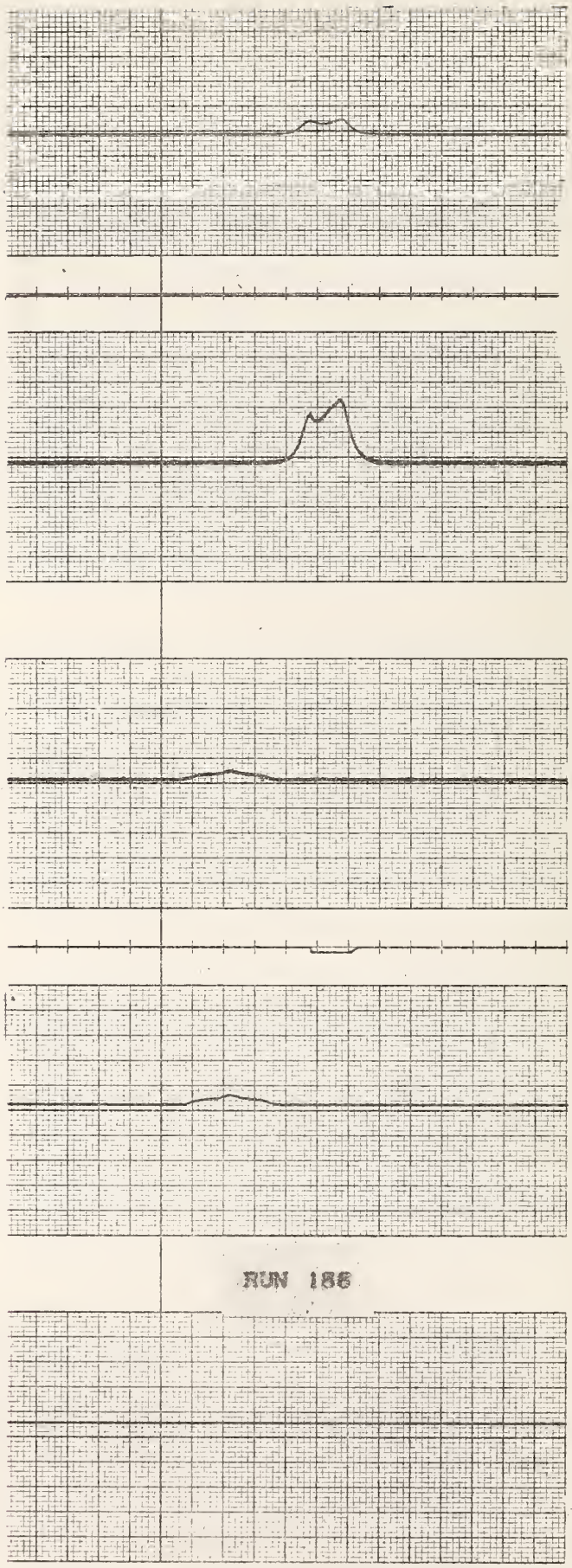
RUN 187

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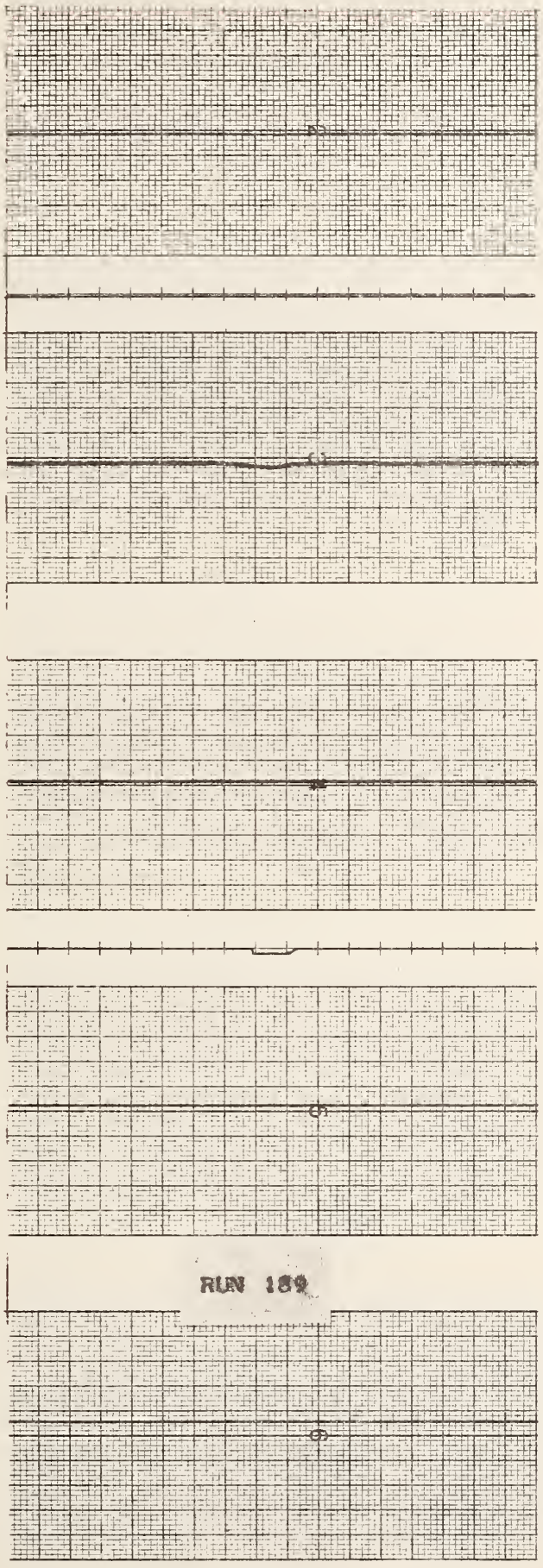
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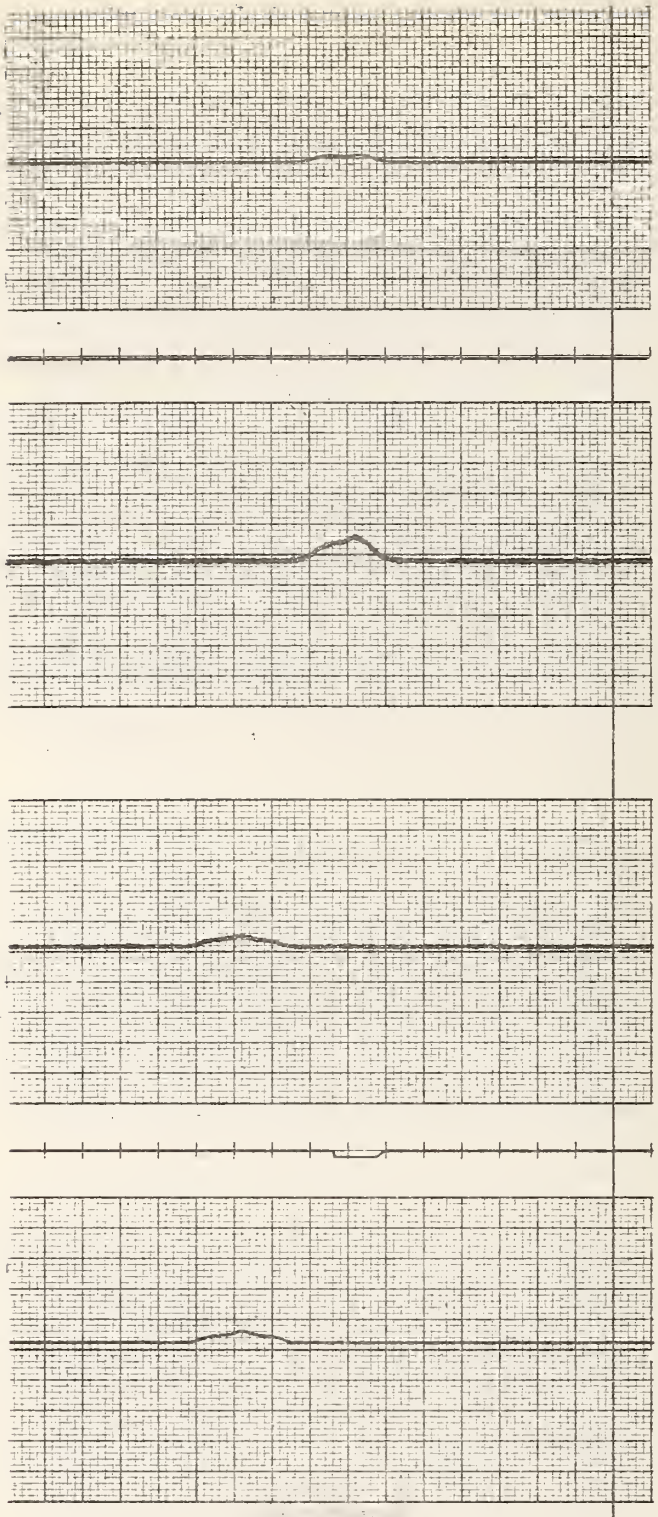
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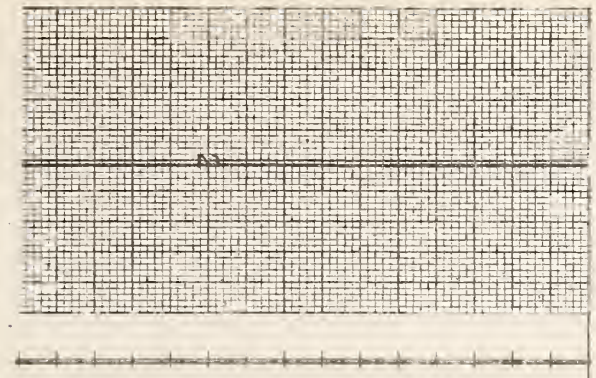

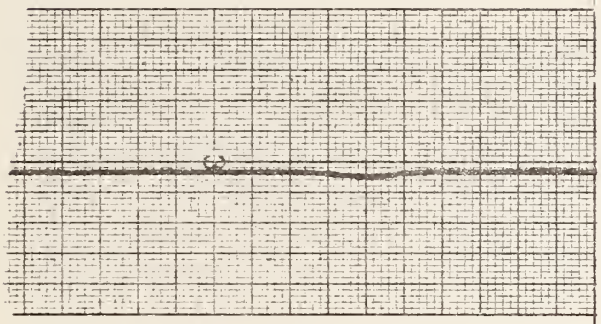

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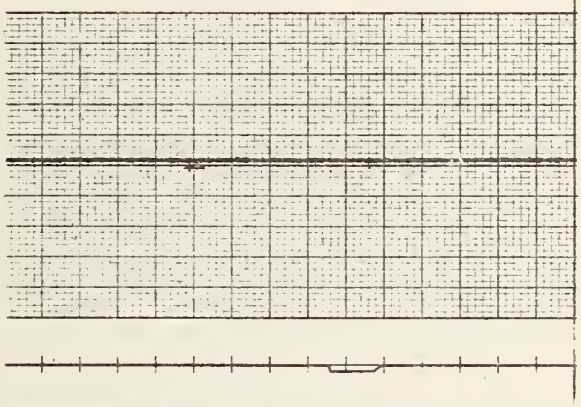

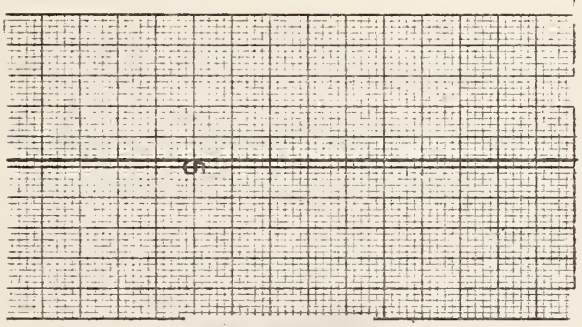

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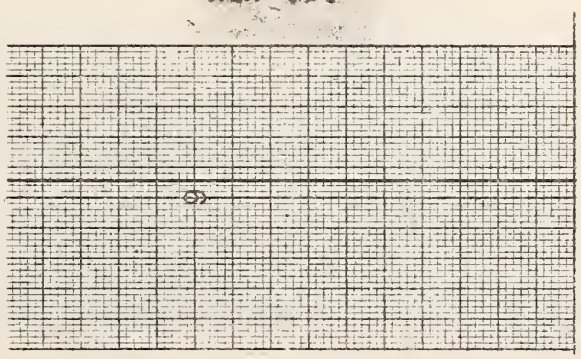

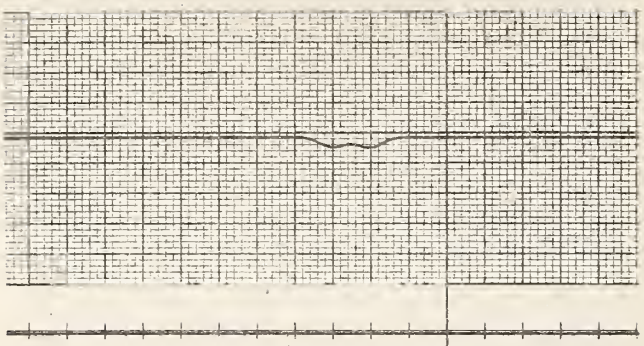

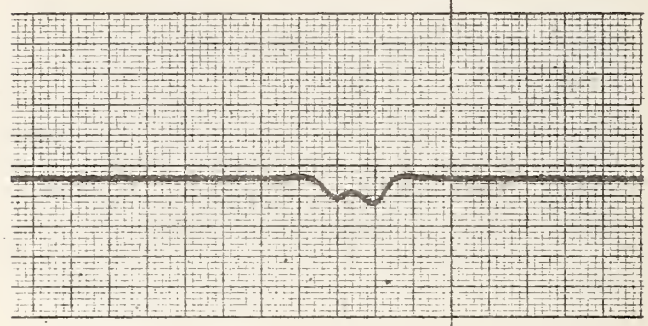

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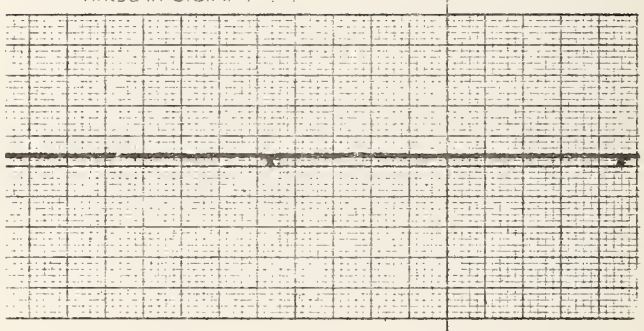

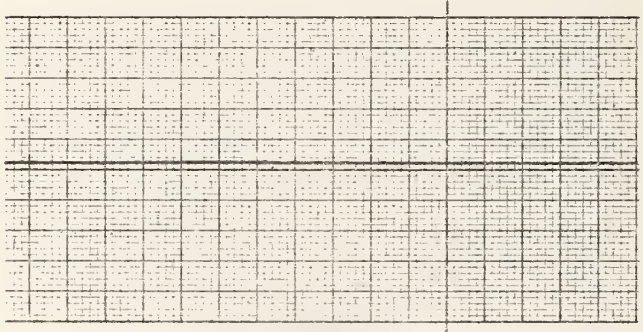

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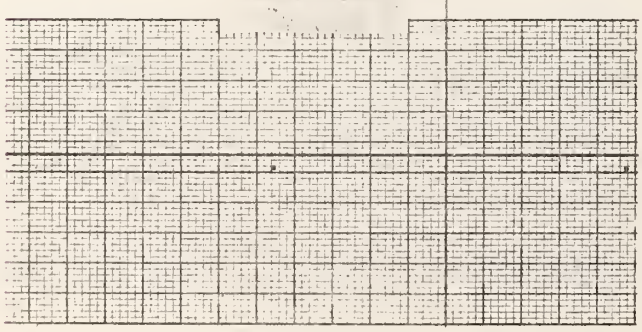

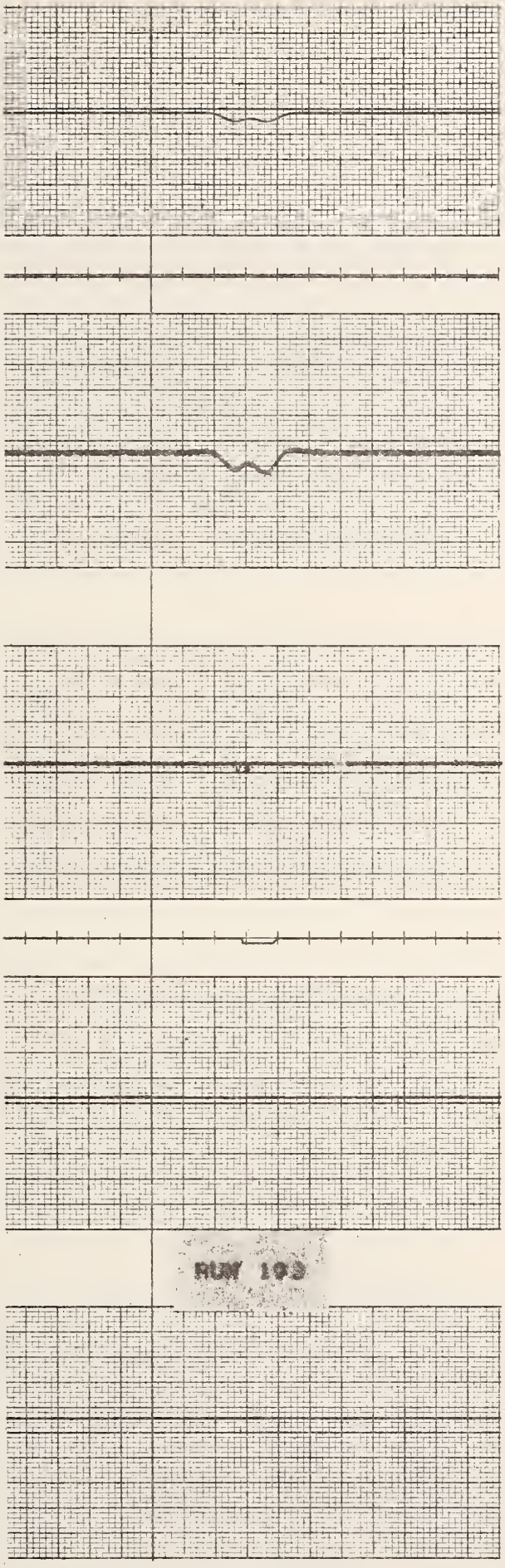
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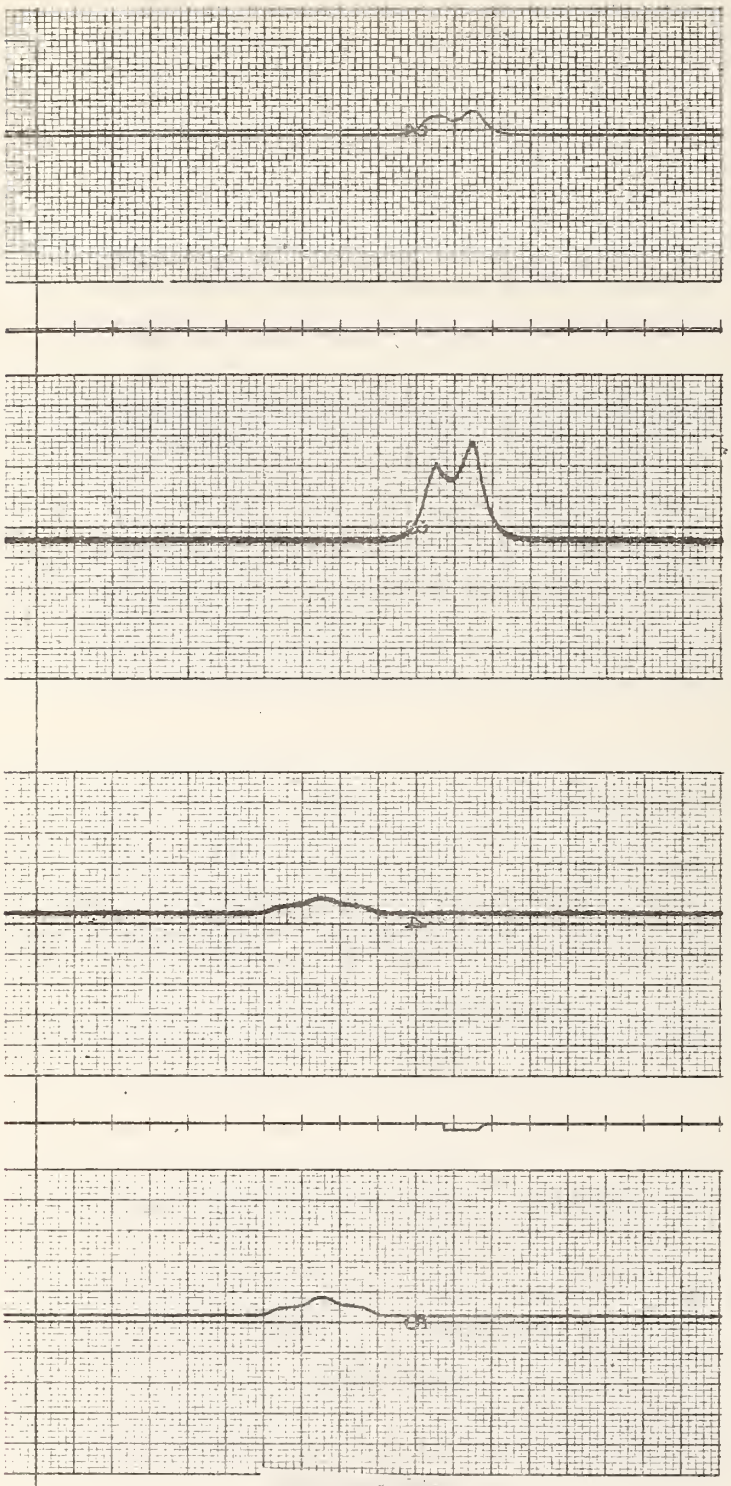
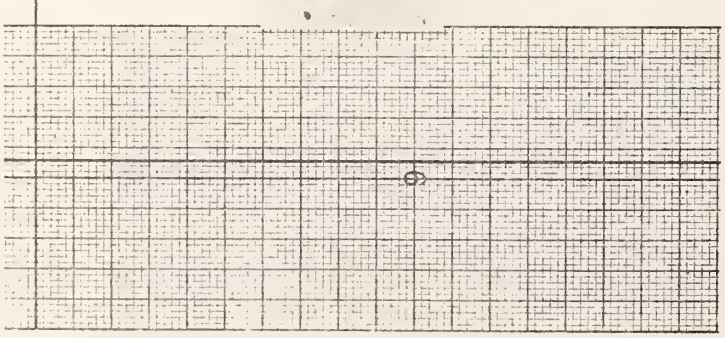
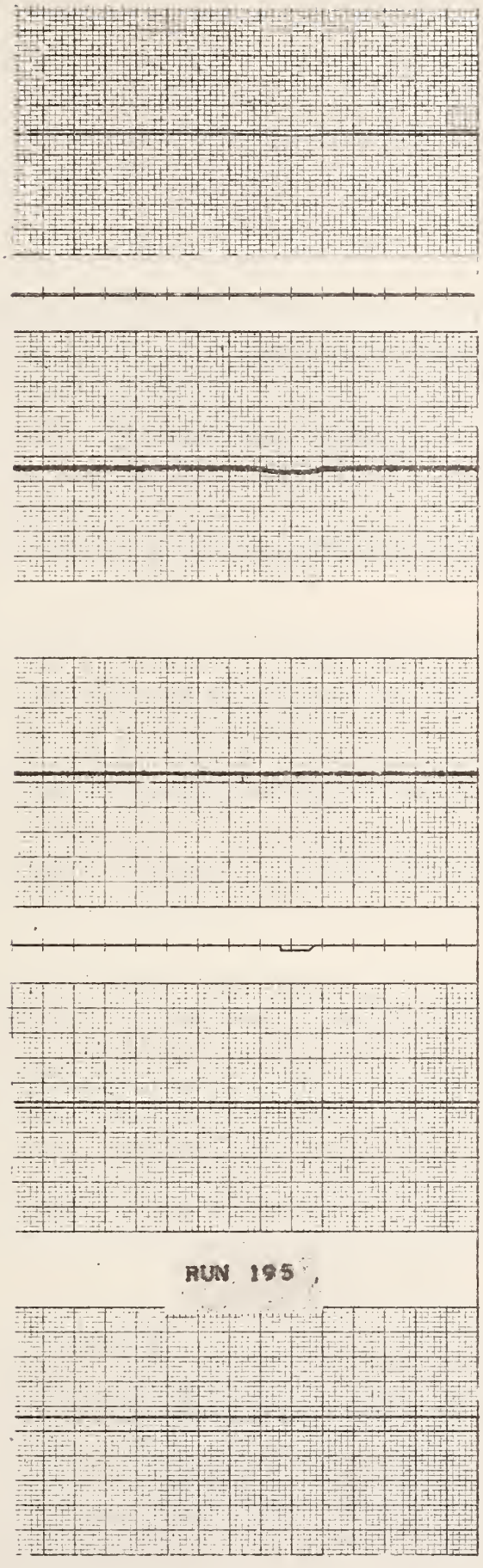


RUN 194

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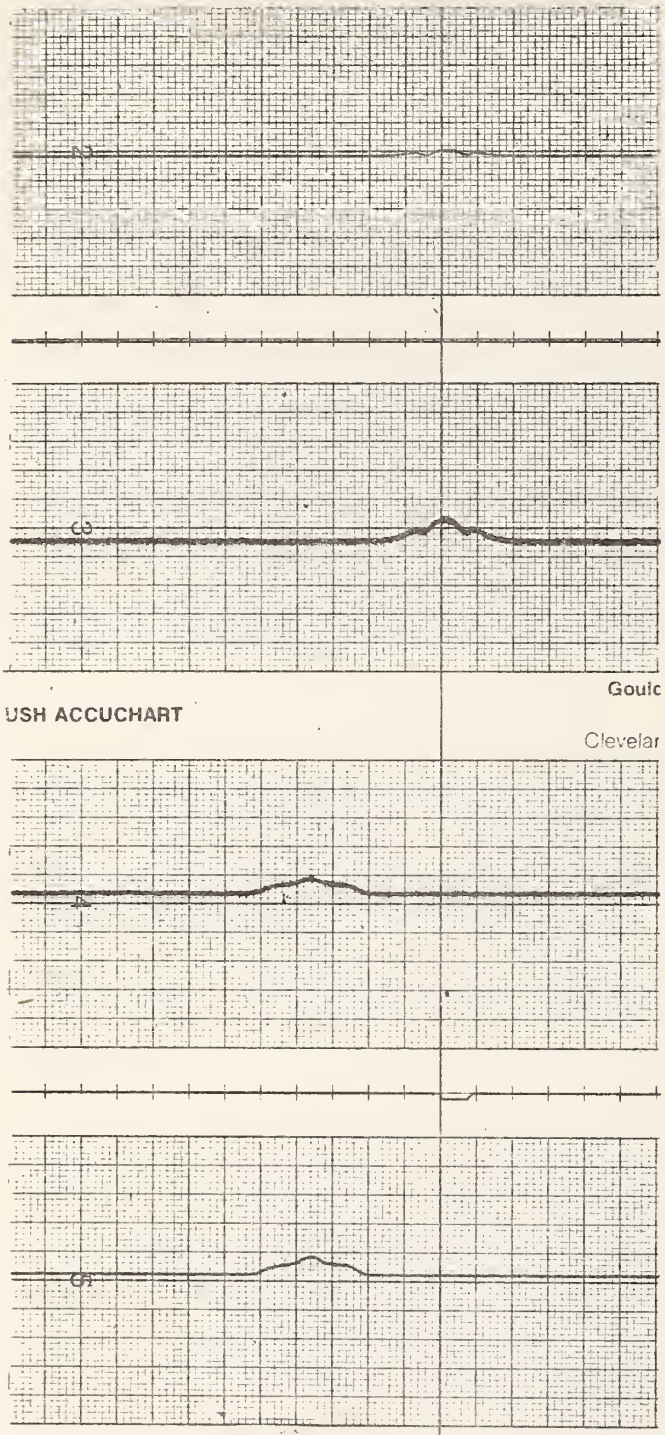
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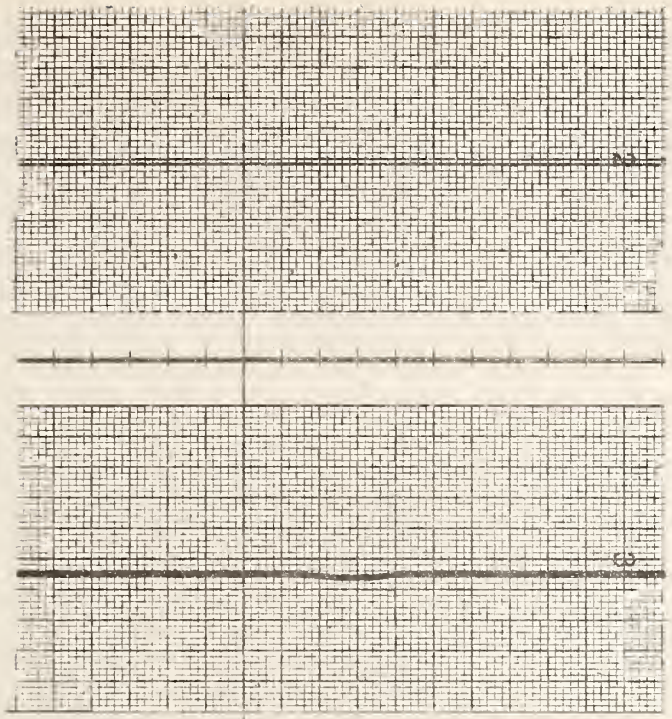
RUN 196



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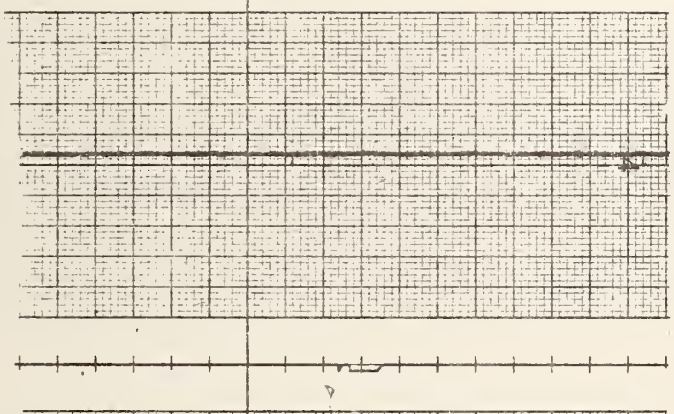
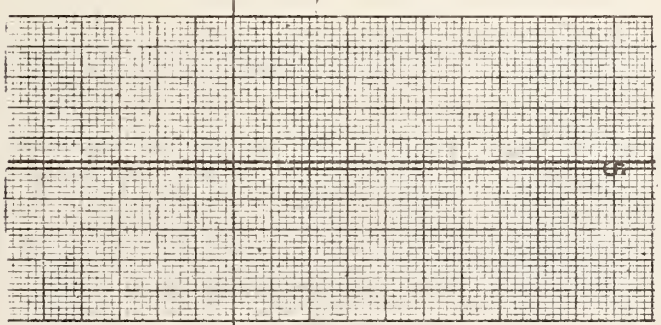
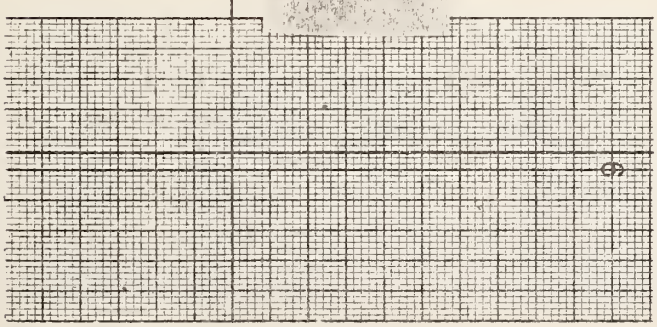
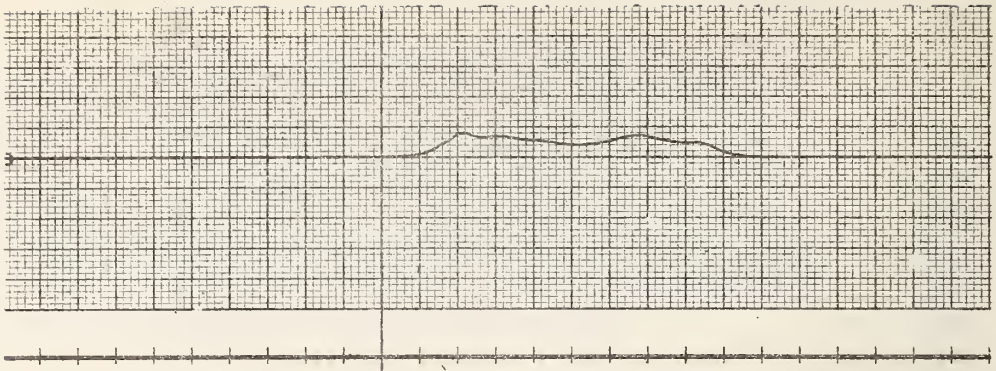
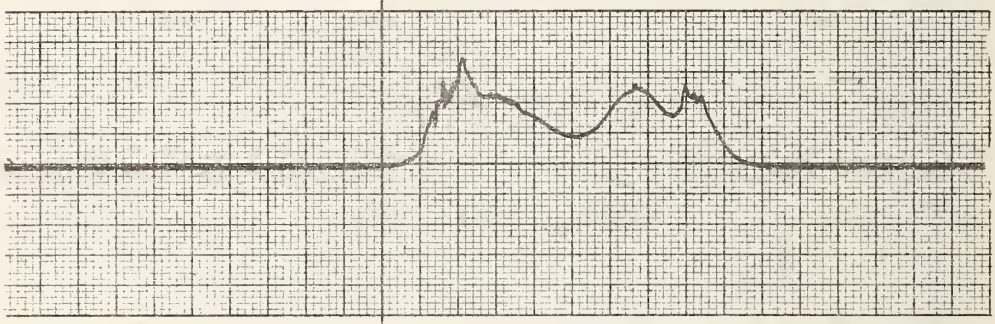




NEW 197







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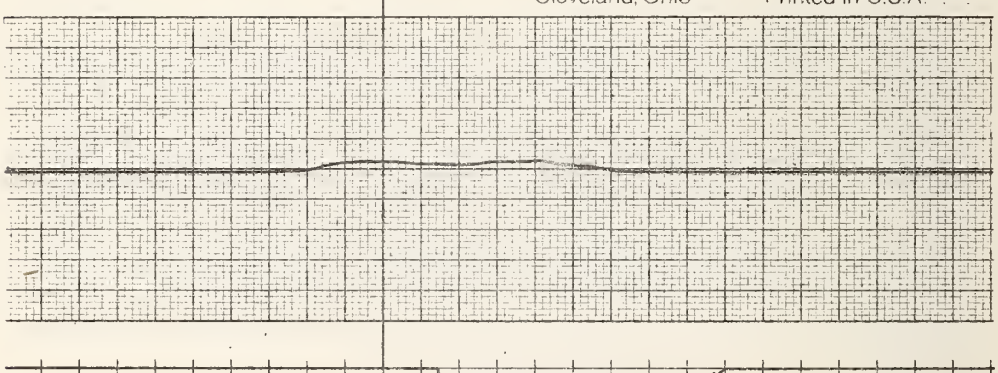
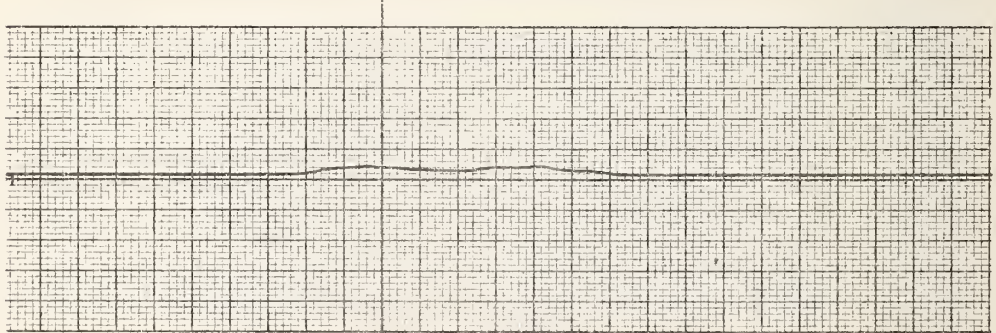
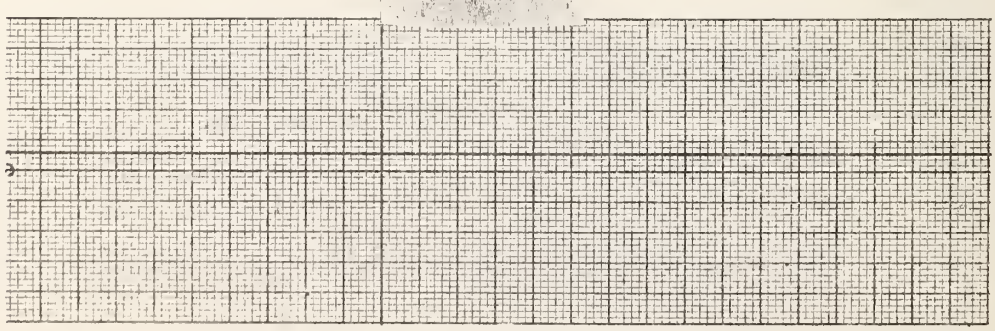
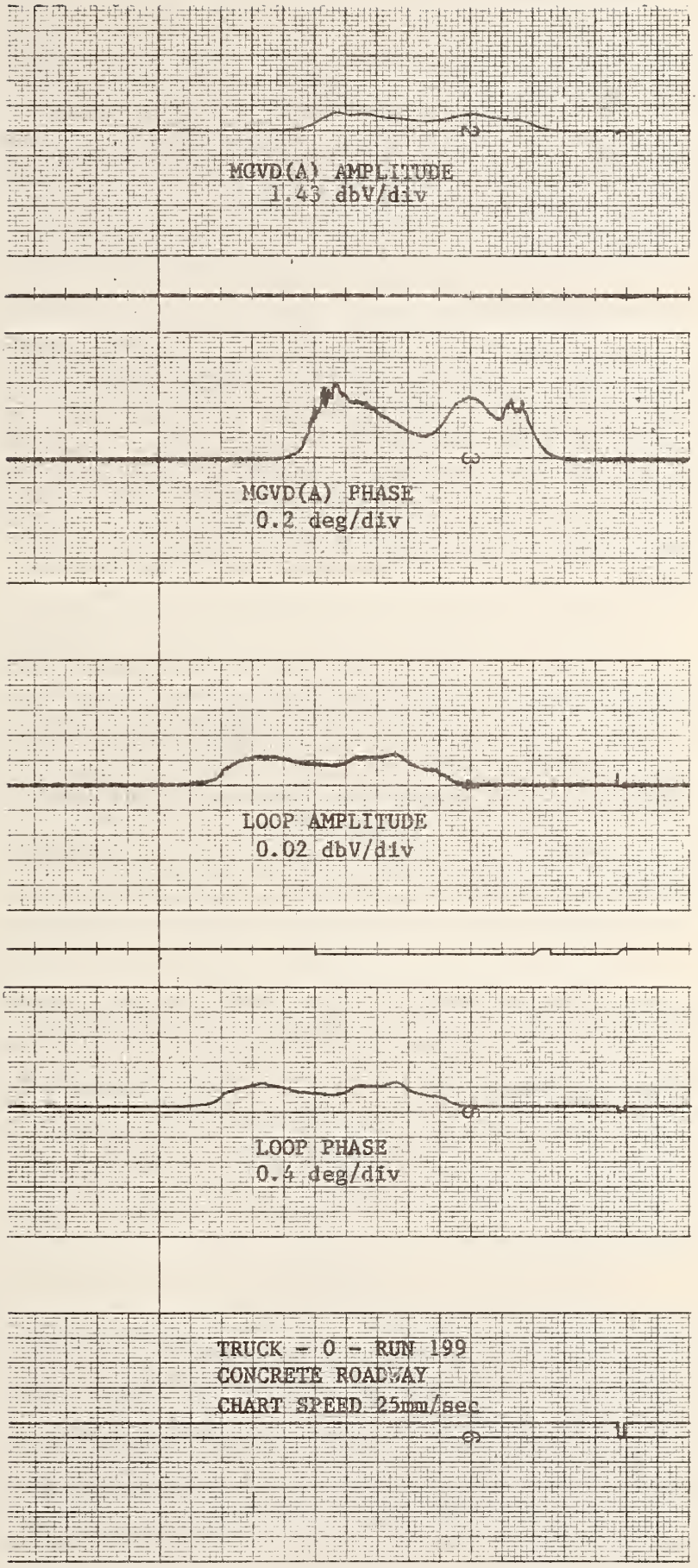
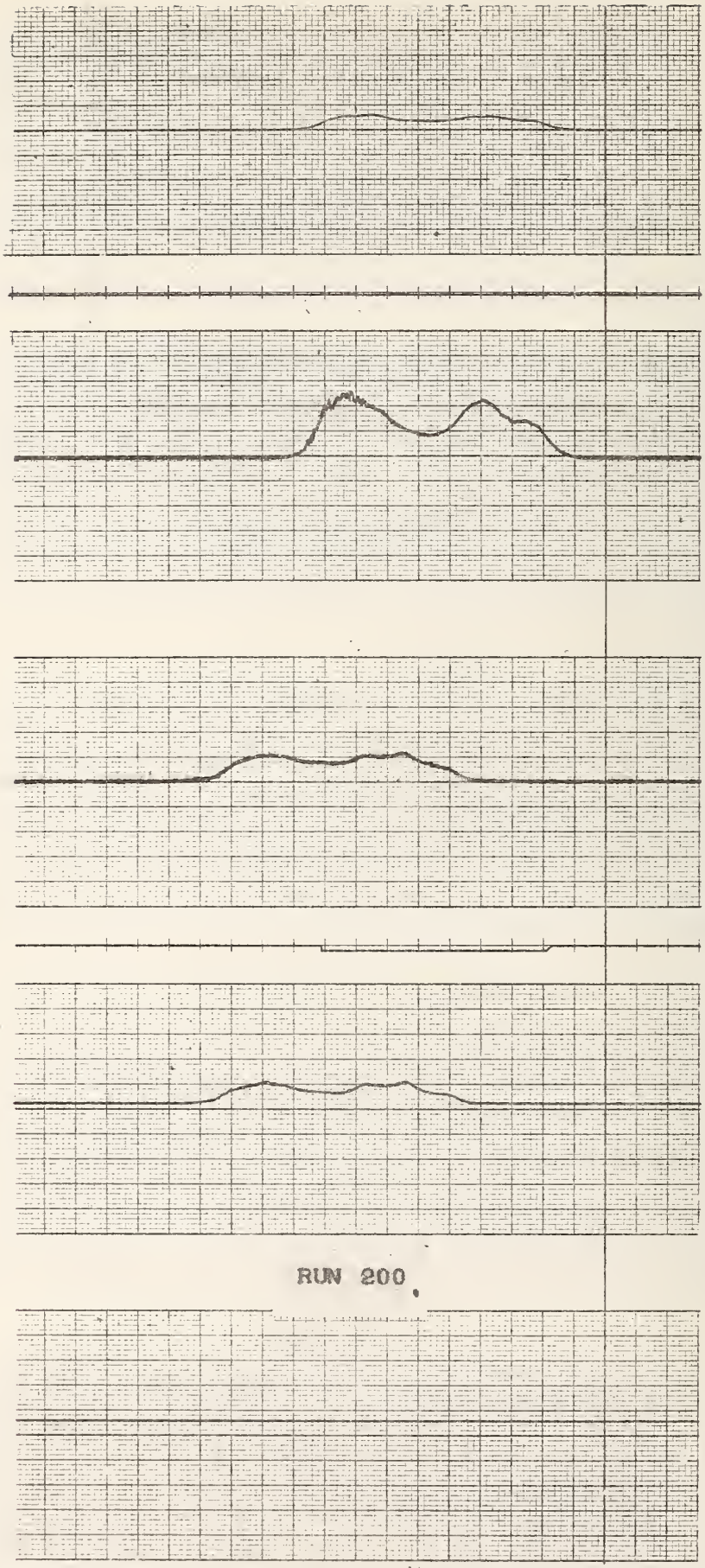


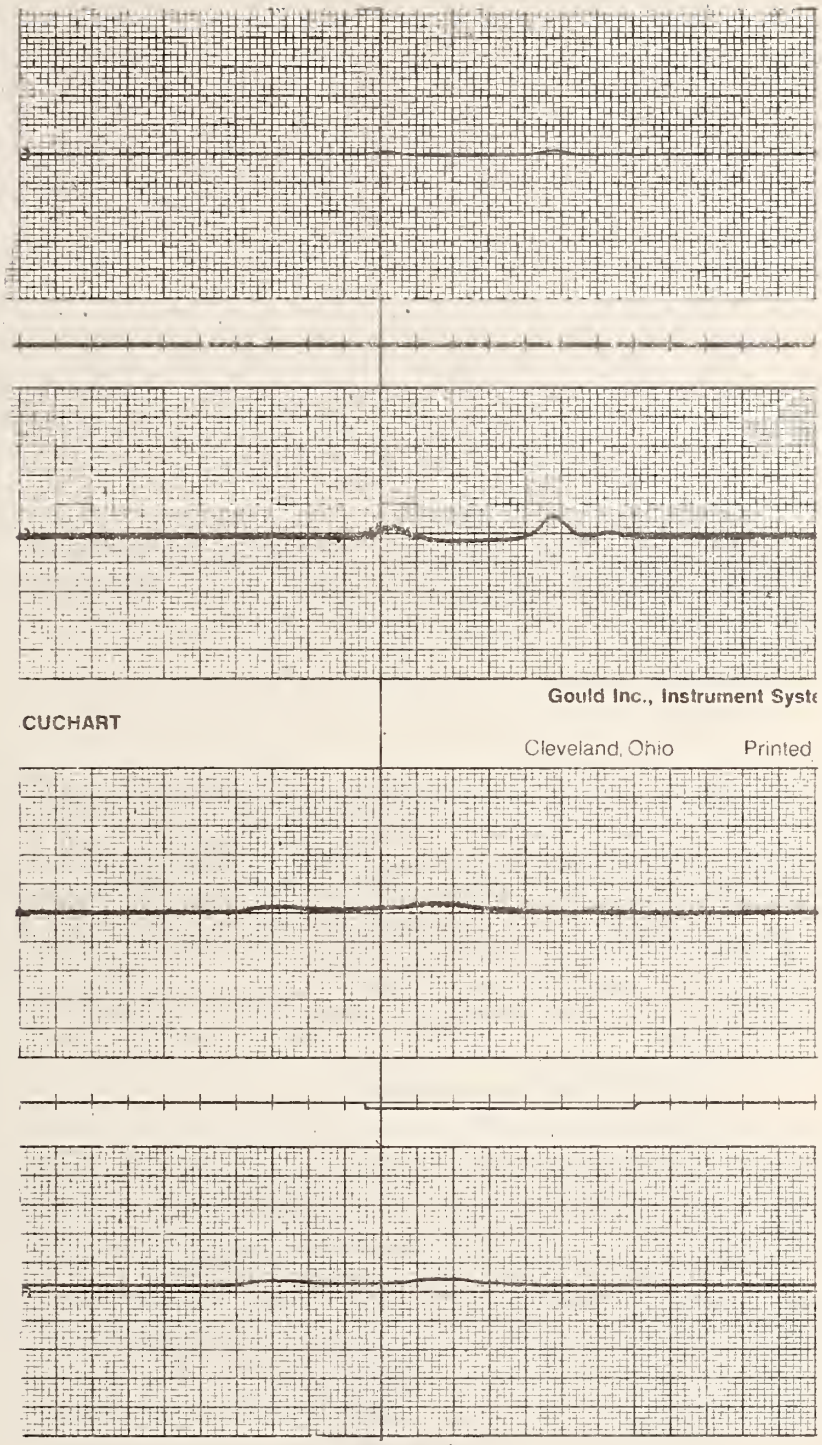


RUN 198

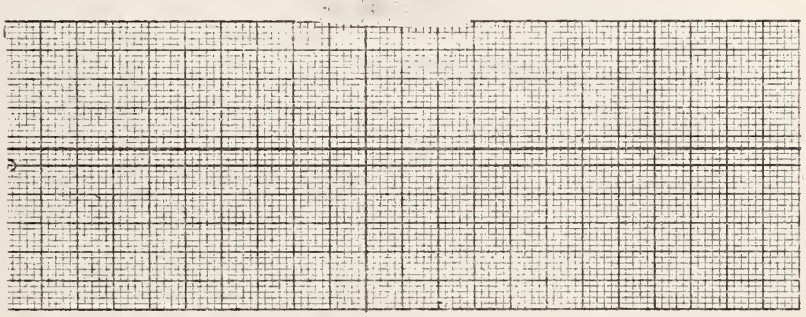


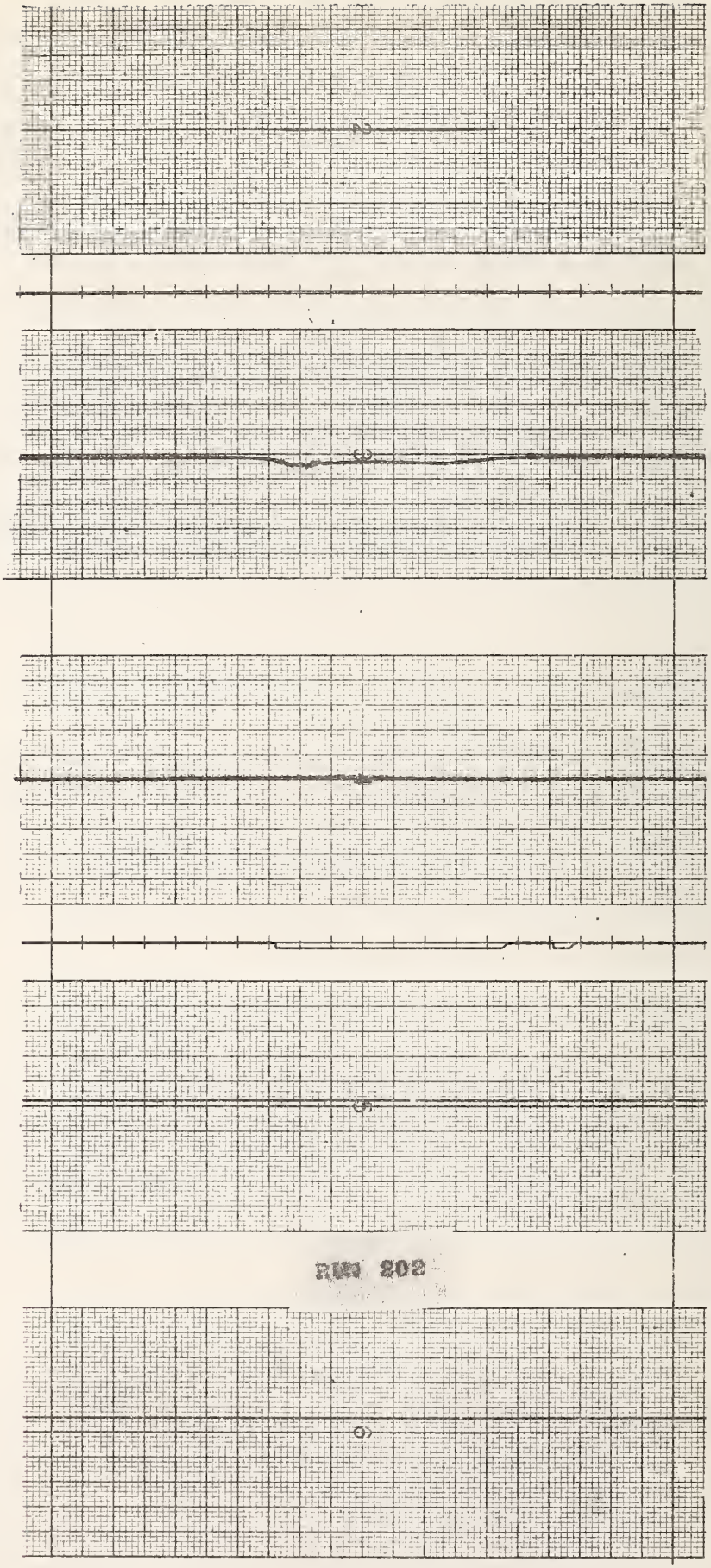

MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
LOOP AMPLITUDE
0.02 dbV/div
LOOP PHASE
0.4 deg/div
TRUCK - 0 - RUN 199
CONCRETE ROADWAY
CHART SPEED 25mm/sec

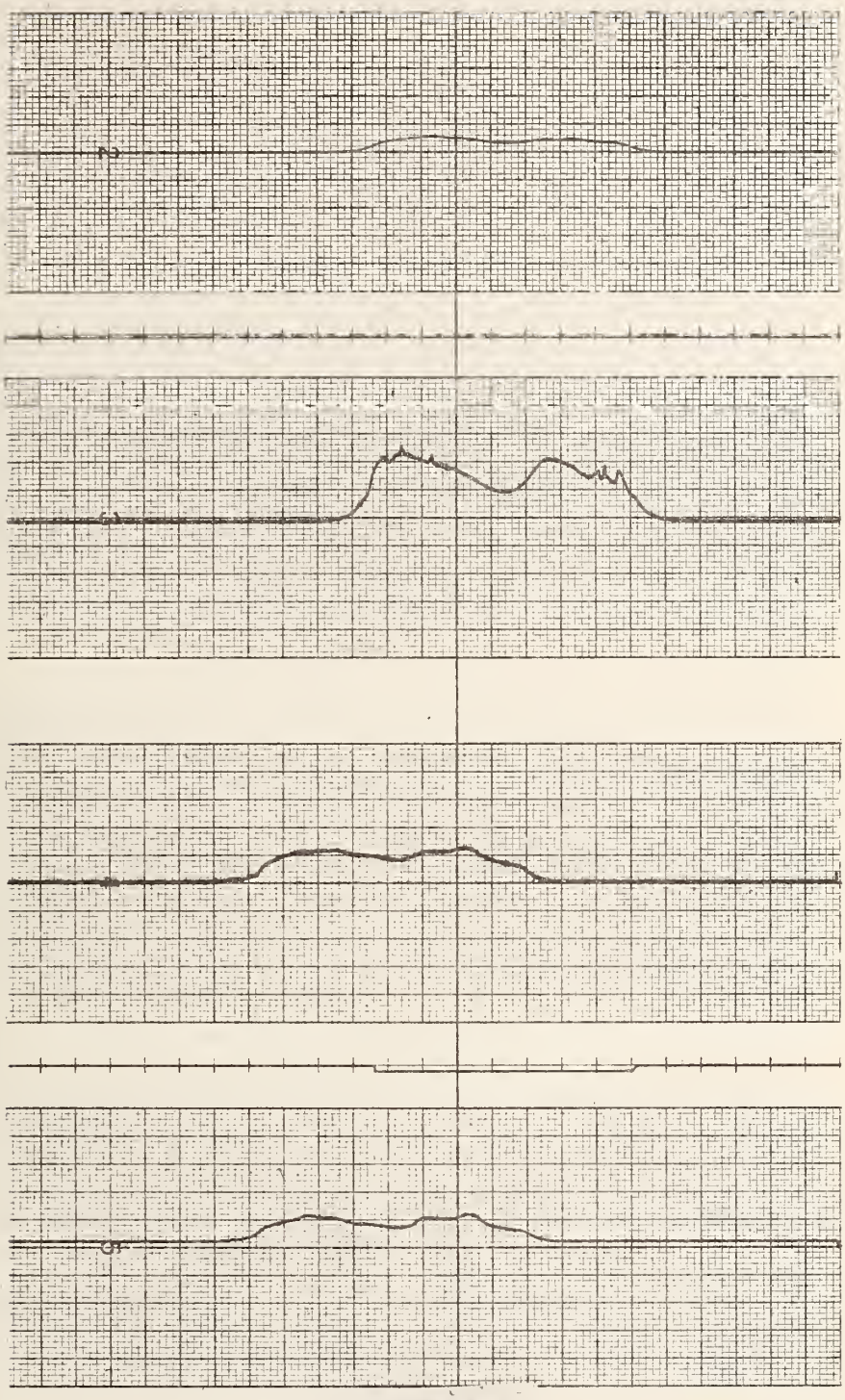

RUN 200


Gould Inc., Instrument Syste
CUCHART
Cleveland, Ohio
Printed

RUN 201







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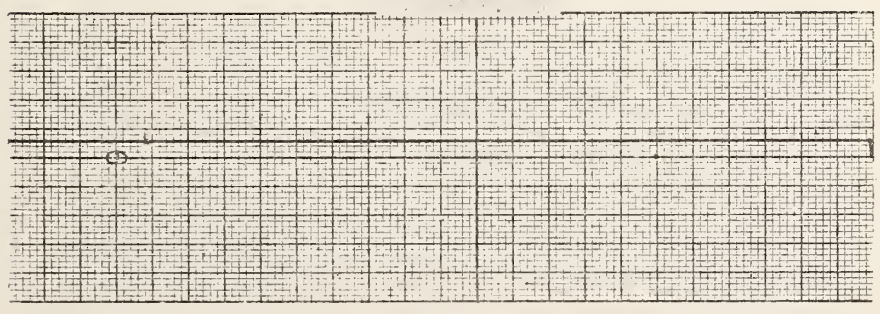
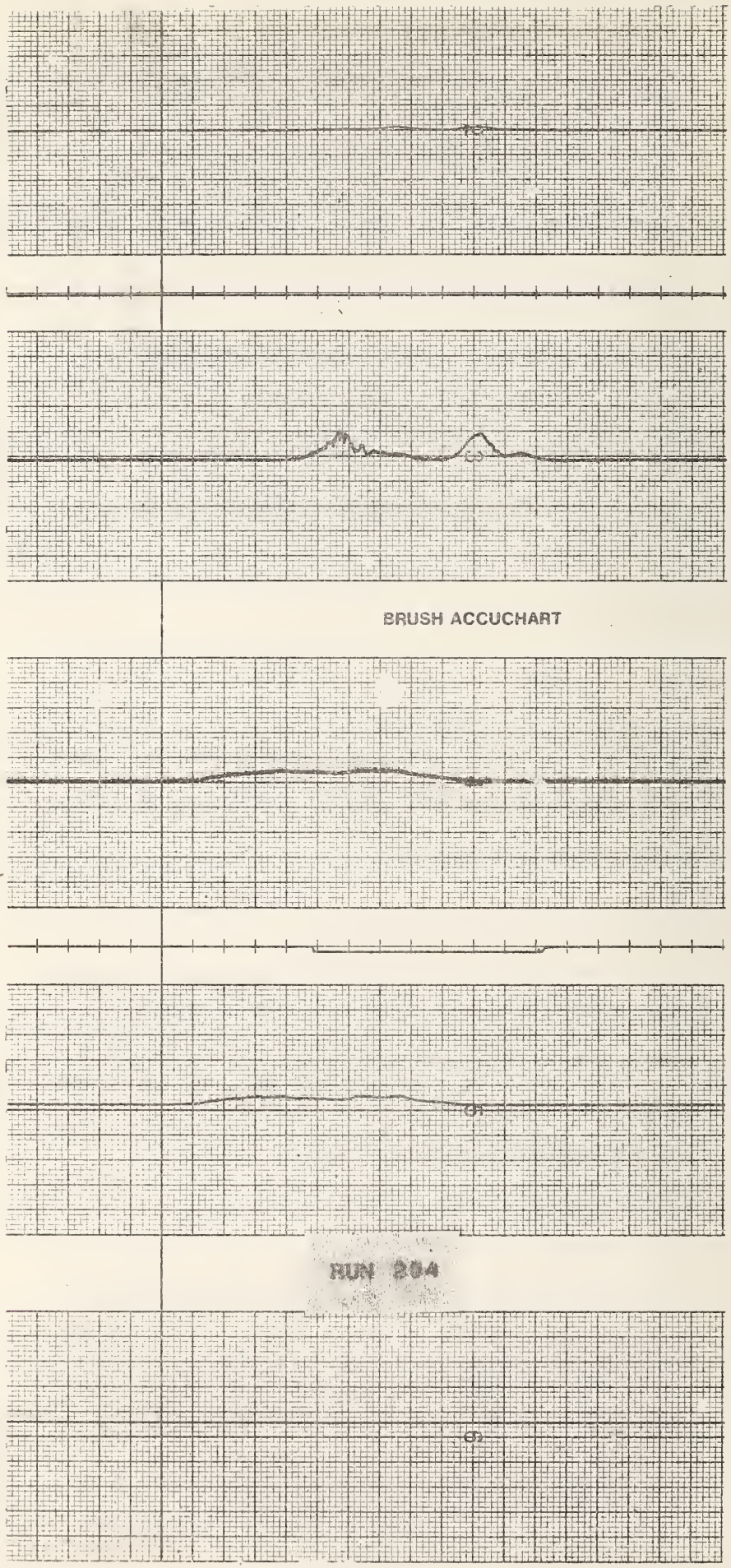
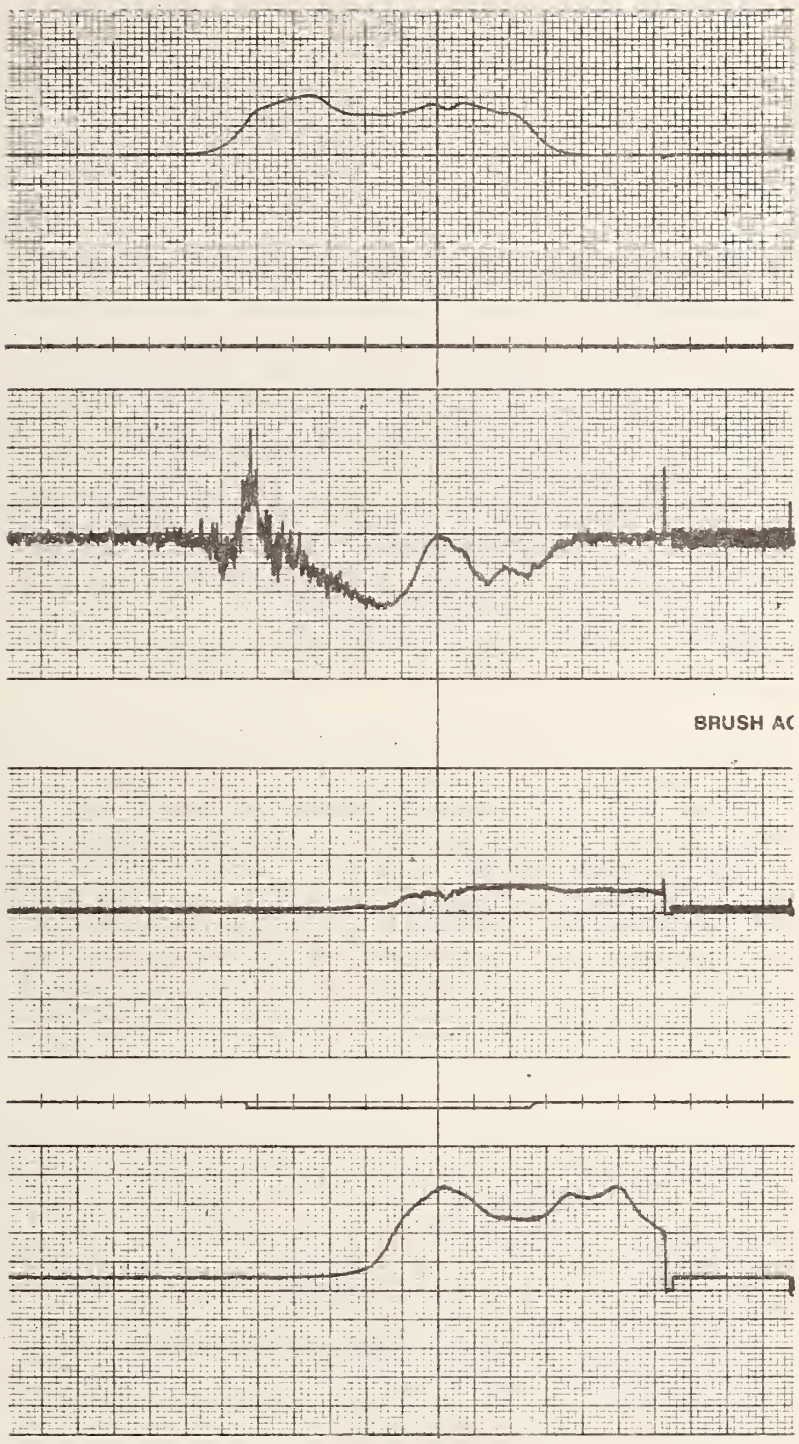
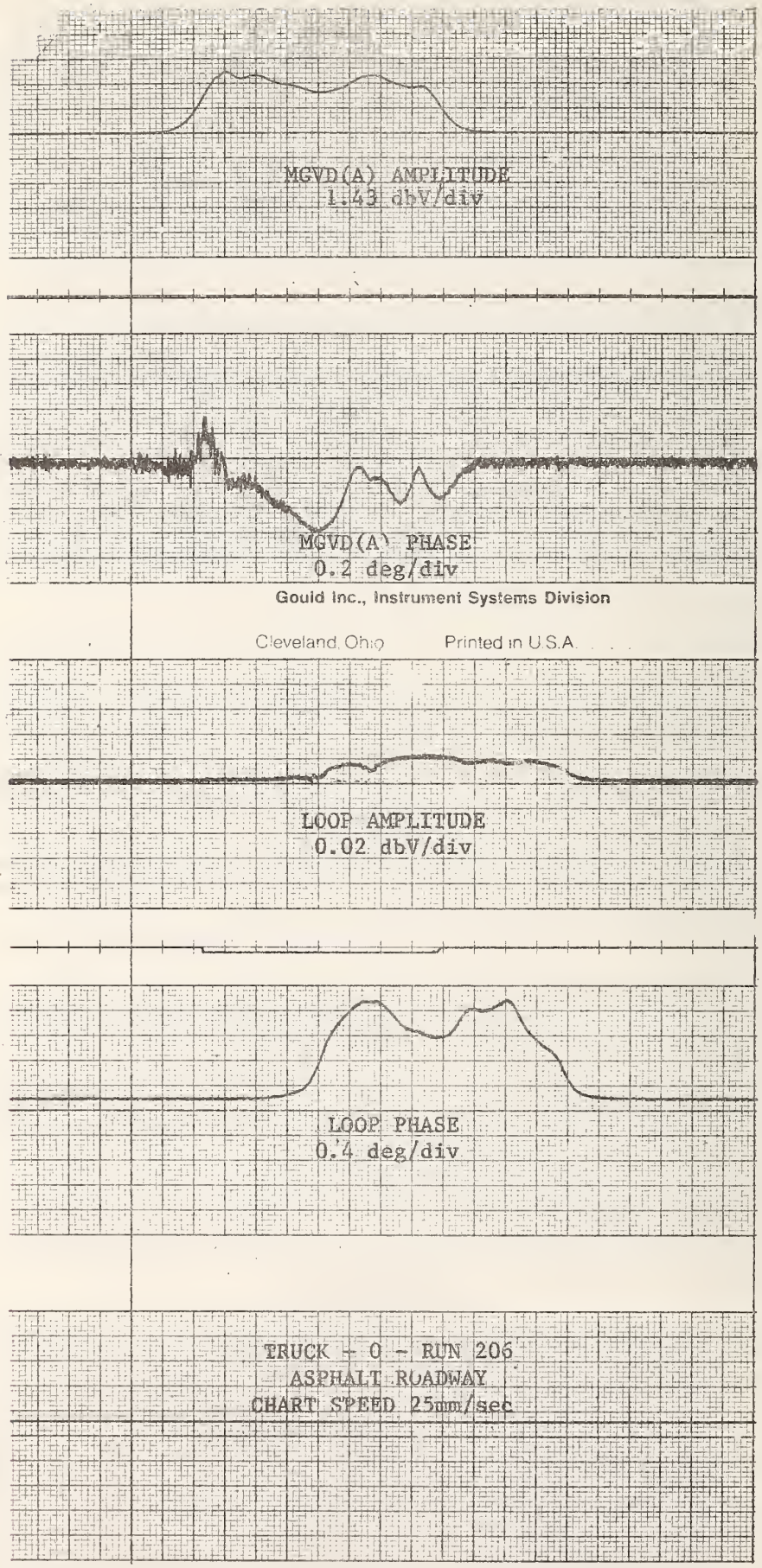



BRUSH ACCUCHART
RUN 264


BRUSH AC
RUN 205


MGVD(A) AMPLITUDE
1.43 dbV/div
MGVD(A) PHASE
0.2 deg/div
Gould Inc., Instrument Systems Division
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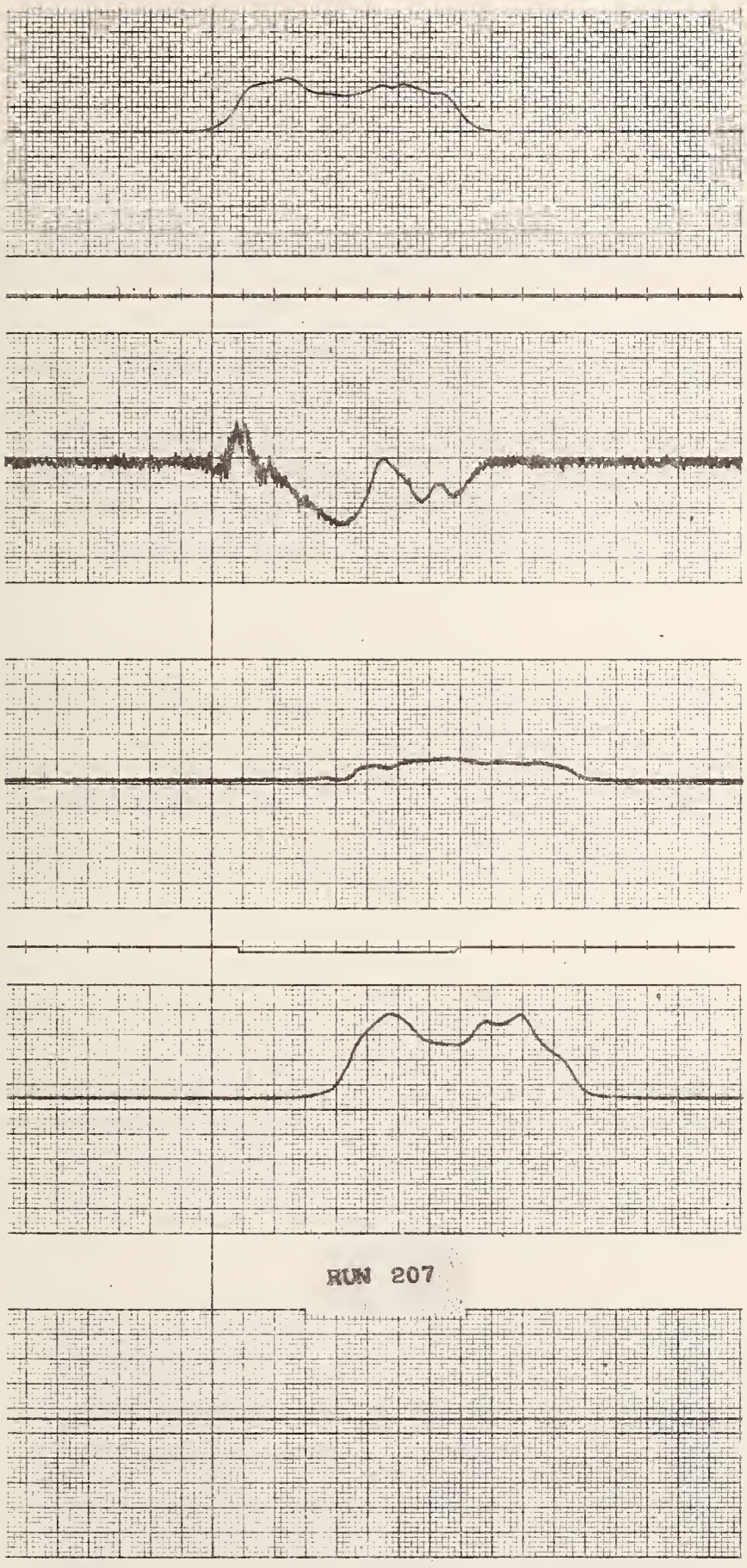
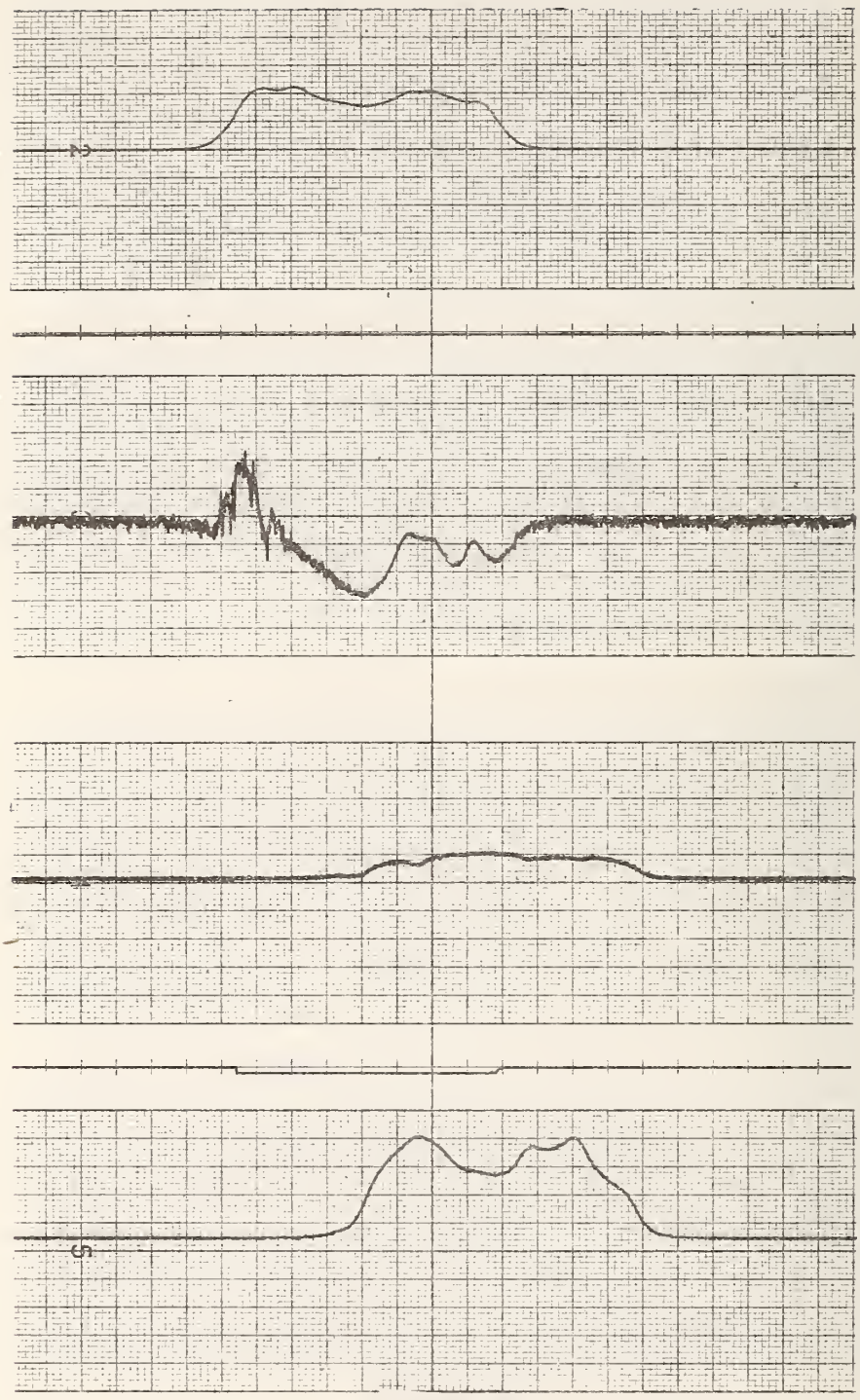
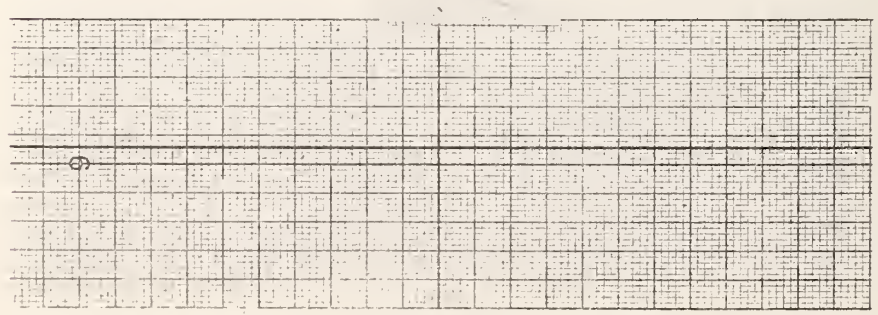
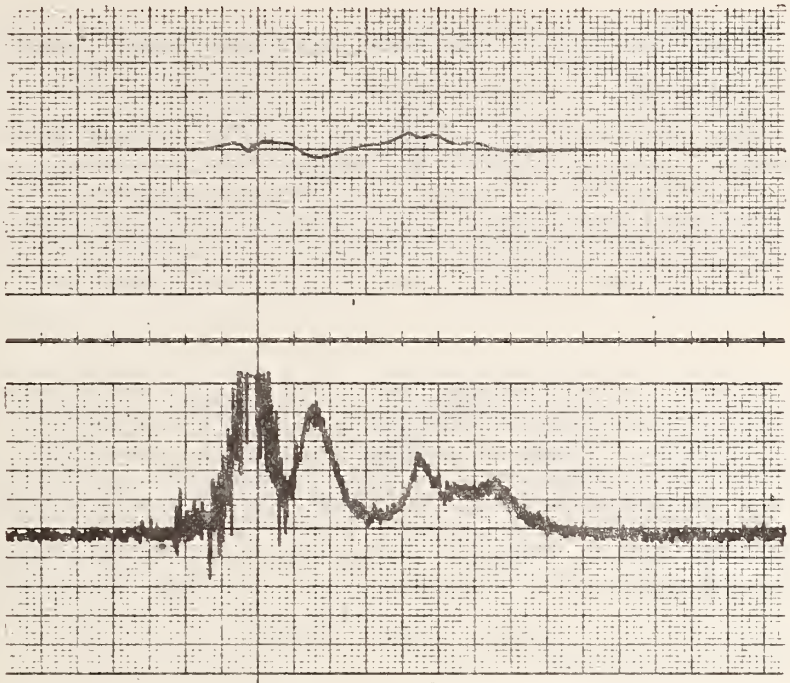
LOOP AMPLITUDE
0.02 dbV/div
LOOP PHASE
0.4 deg/div
TRUCK - 0 - RUN 206
ASPHALT ROADWAY
CHART SPEED 25mm/sec


RUN 207



RUN 208





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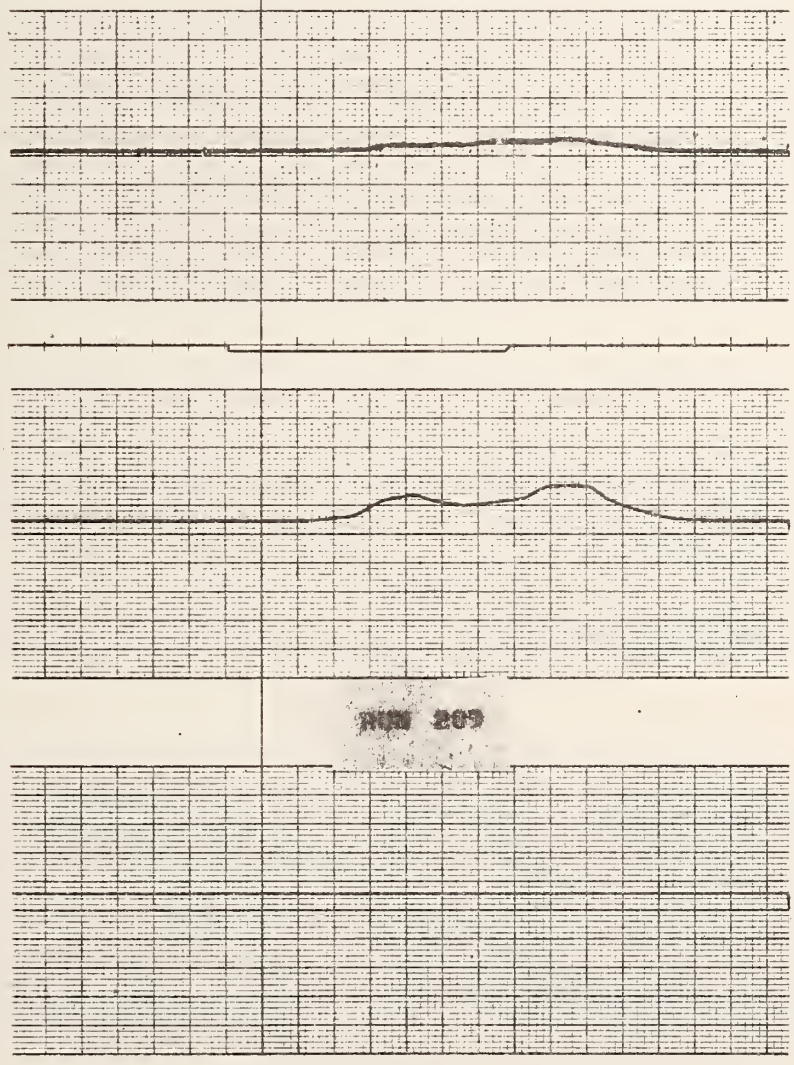
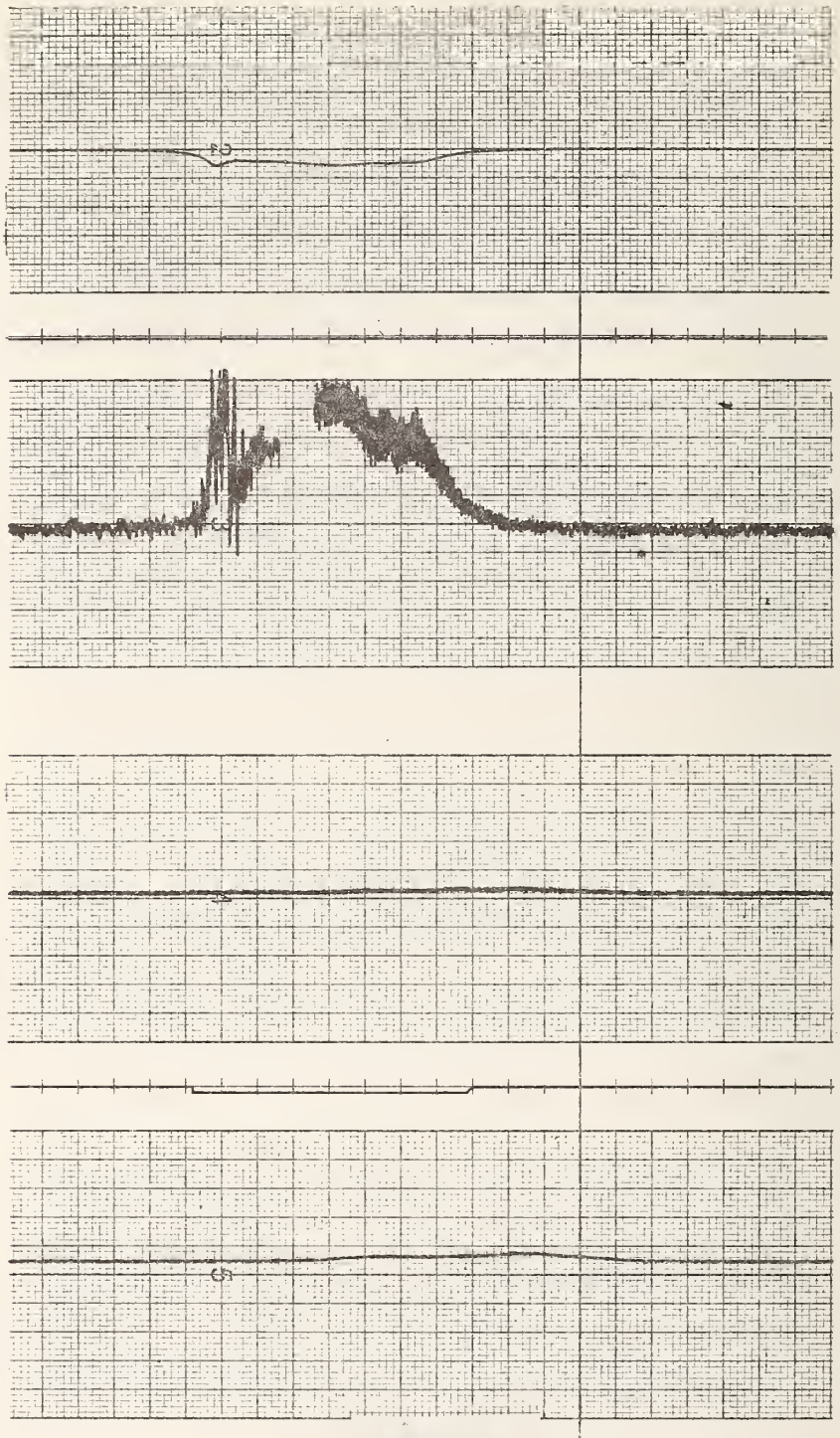
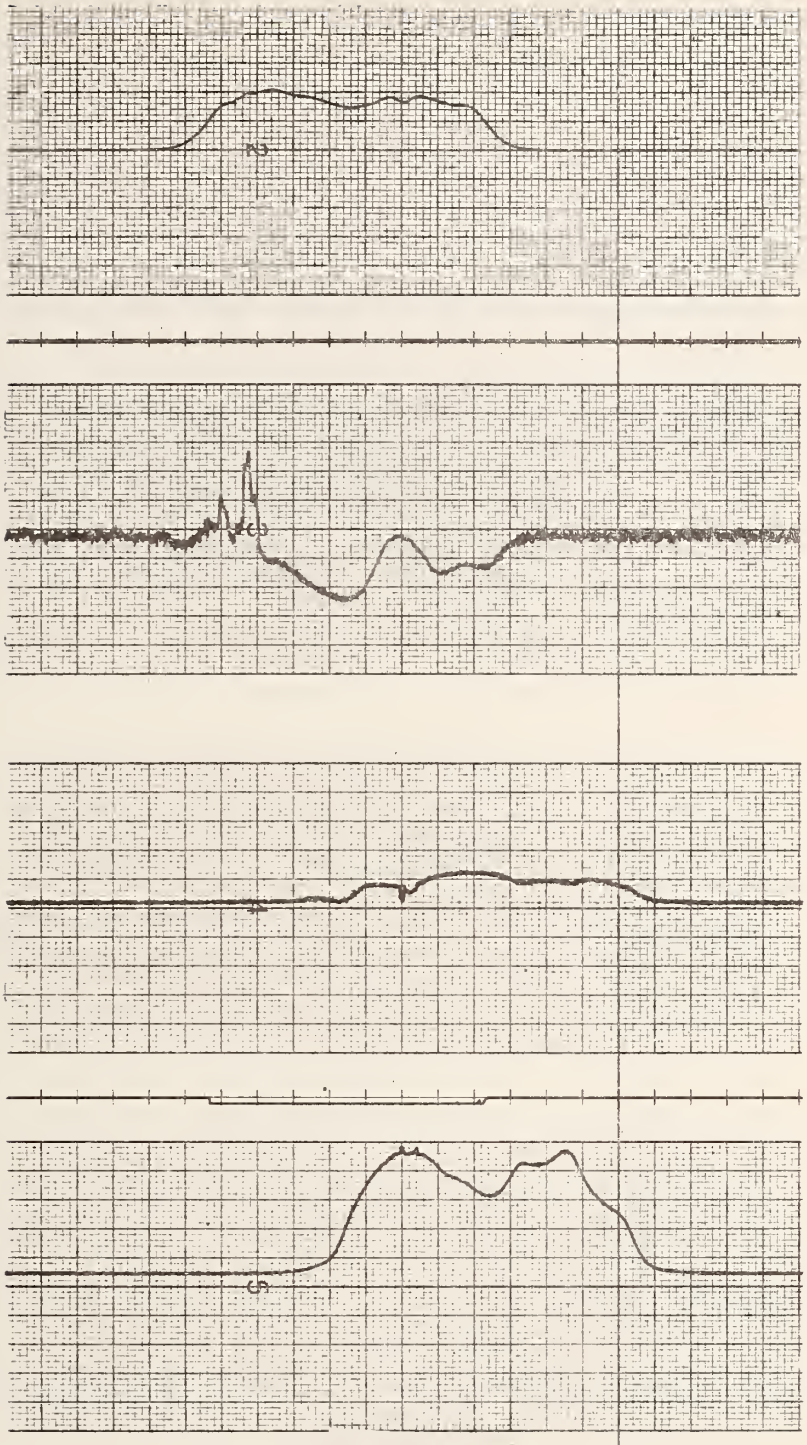
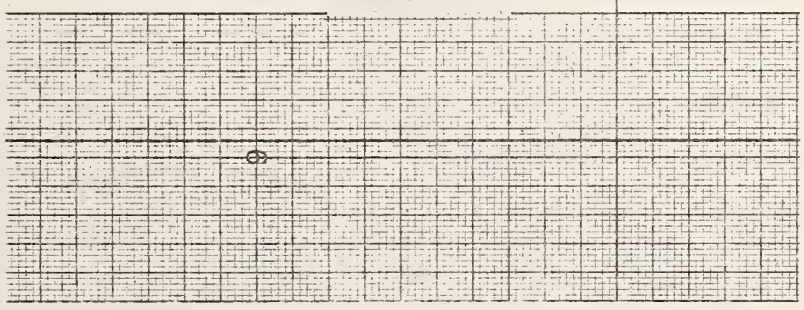


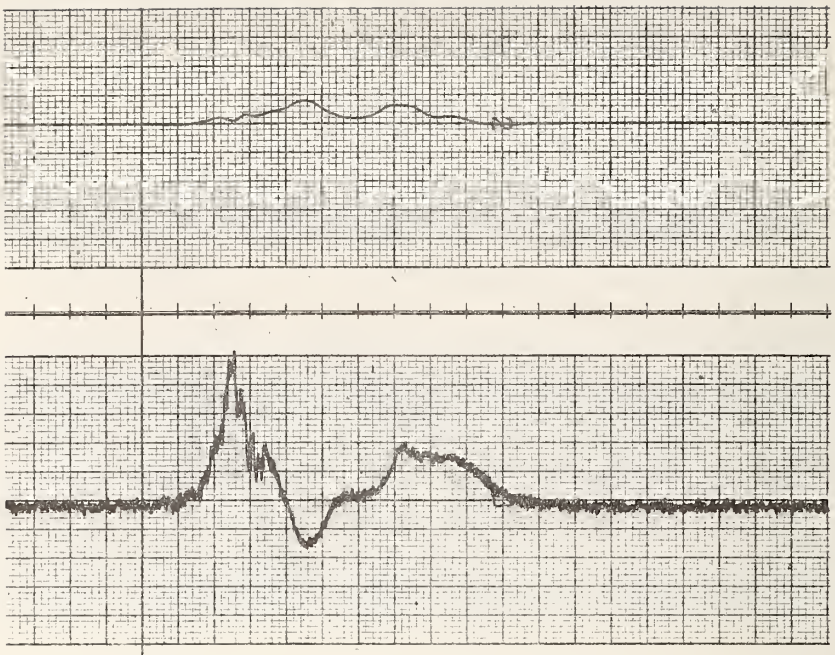


RUN 210



RUN 211





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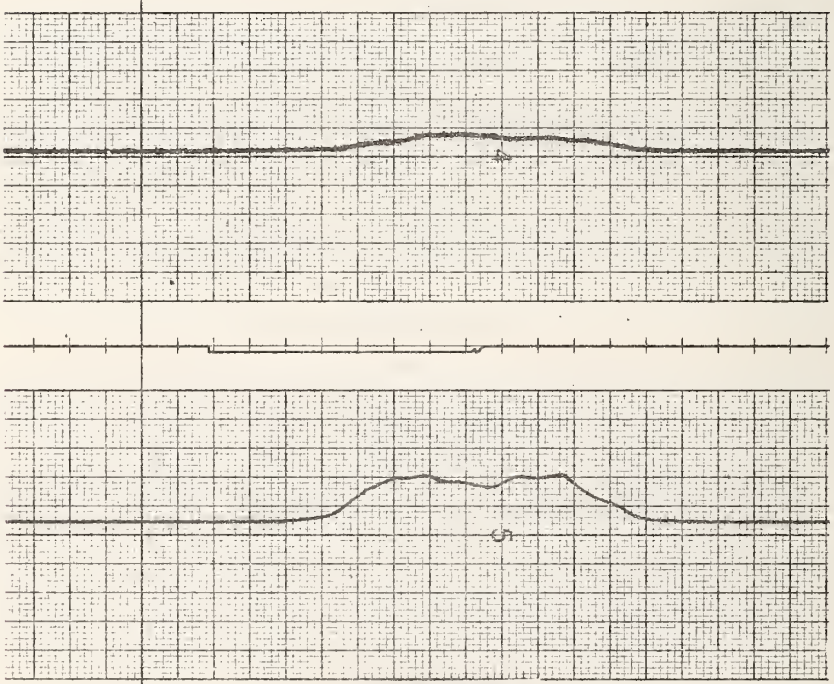

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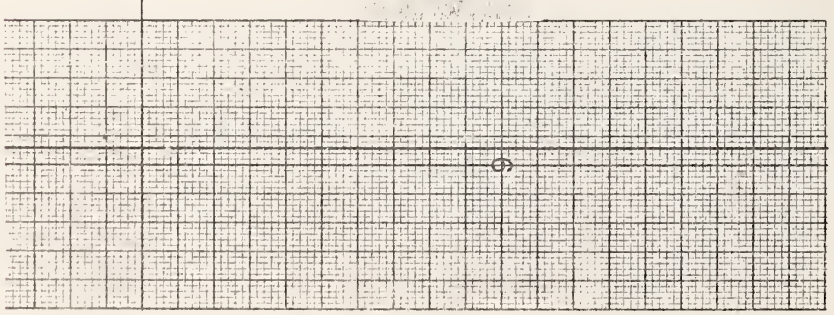
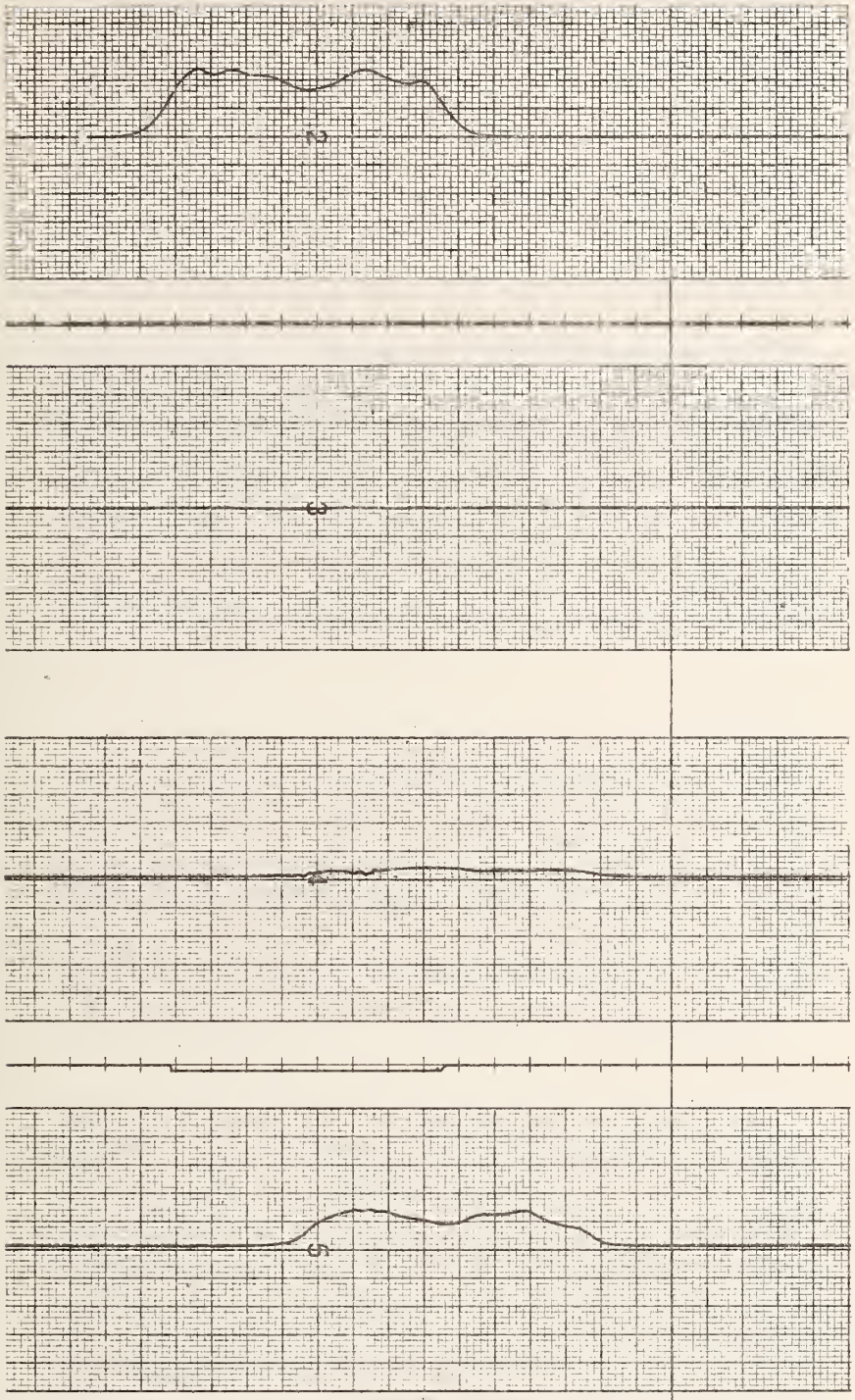
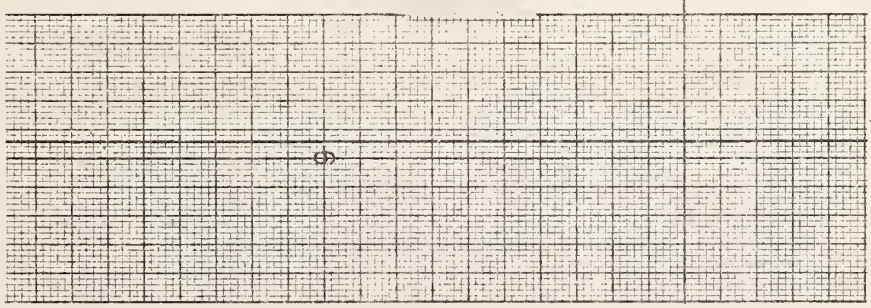
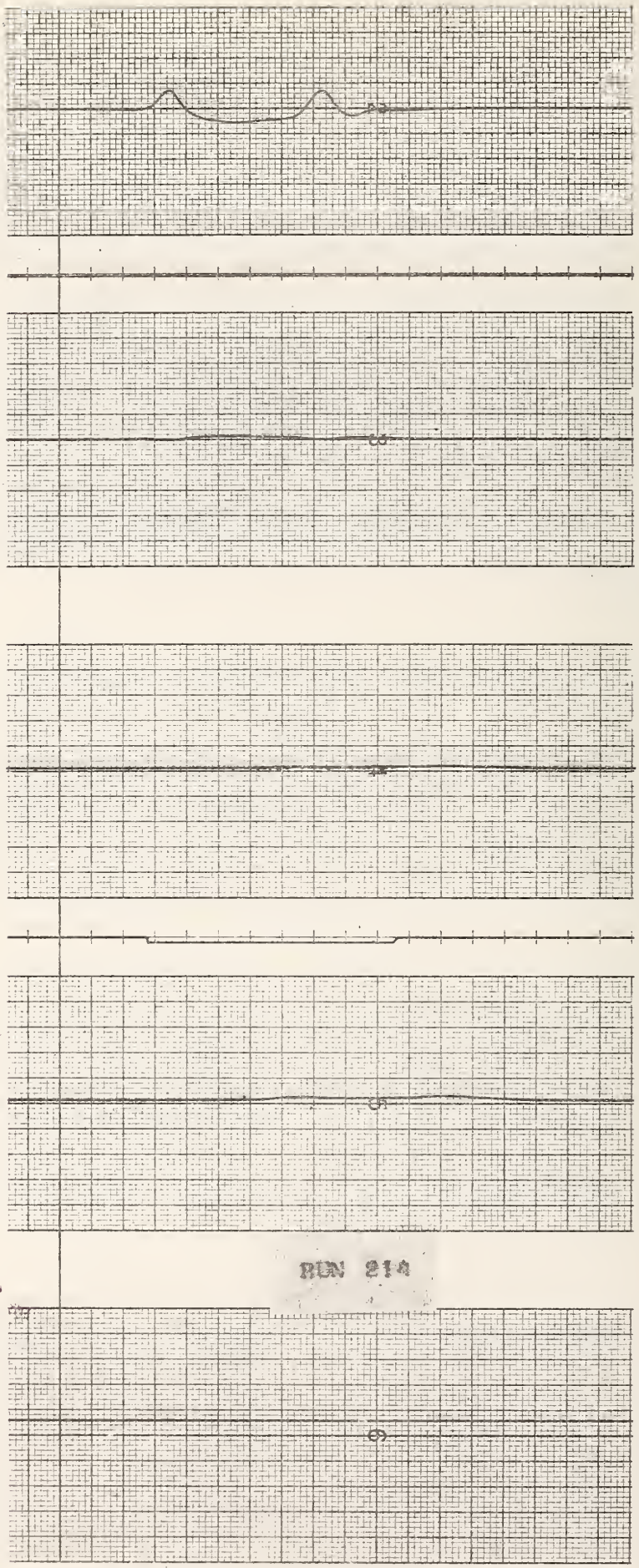




RUN 213

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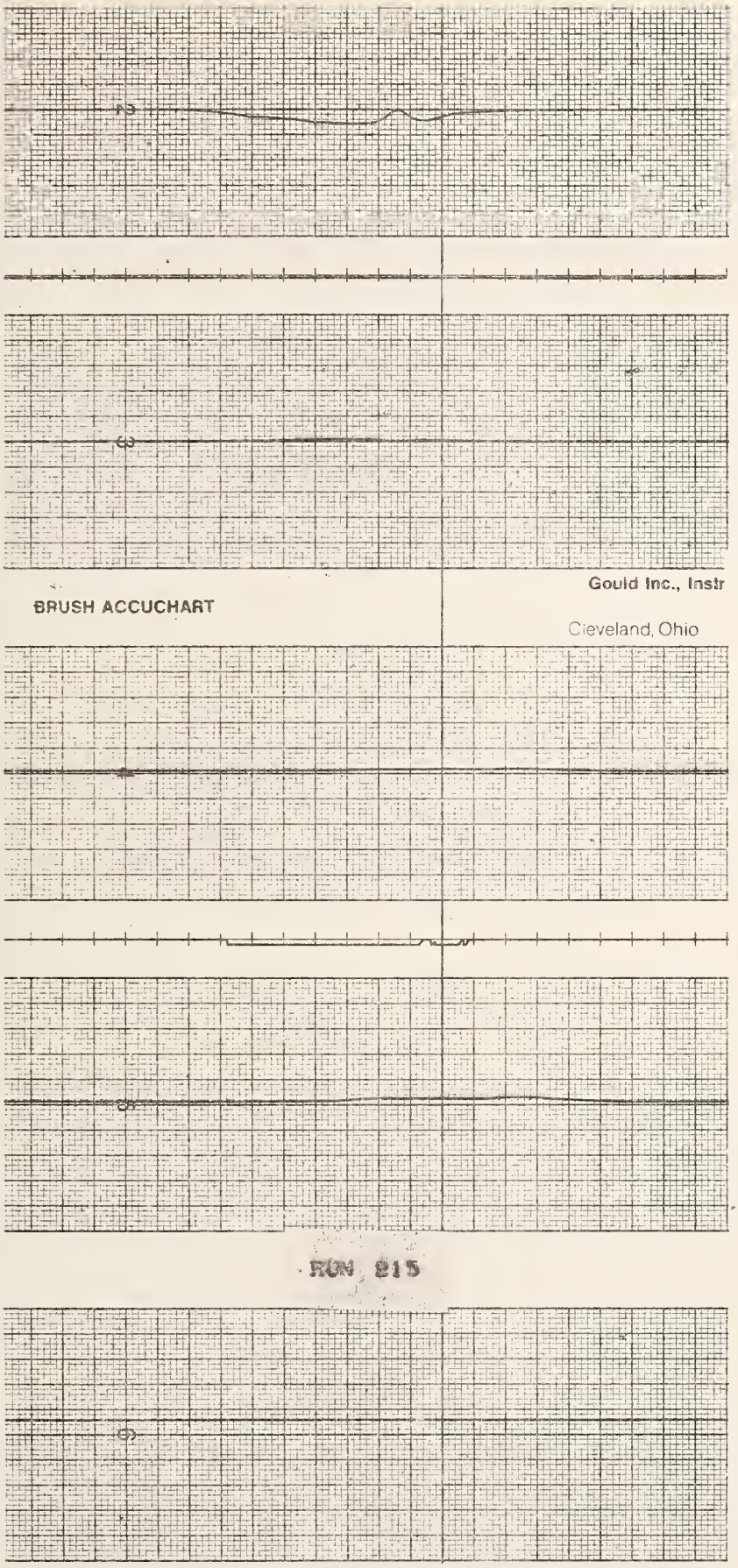

RON 815

Run 216

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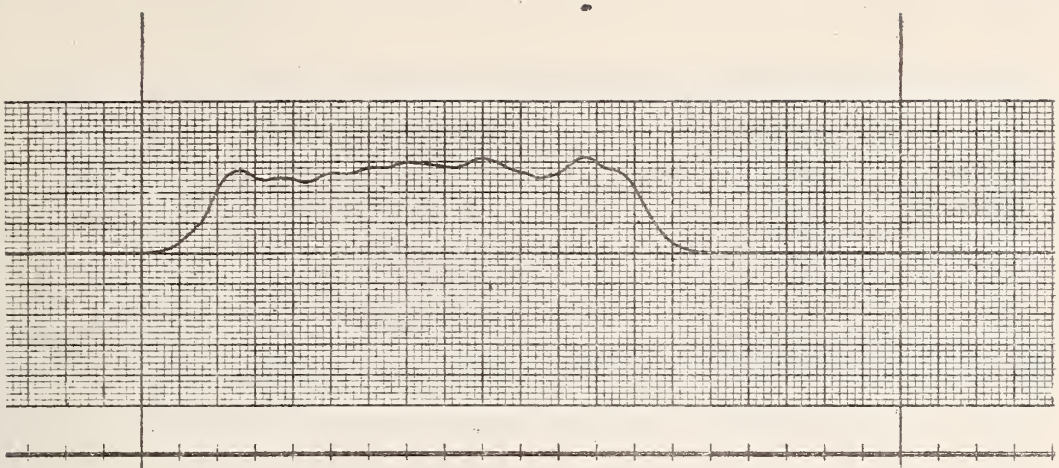

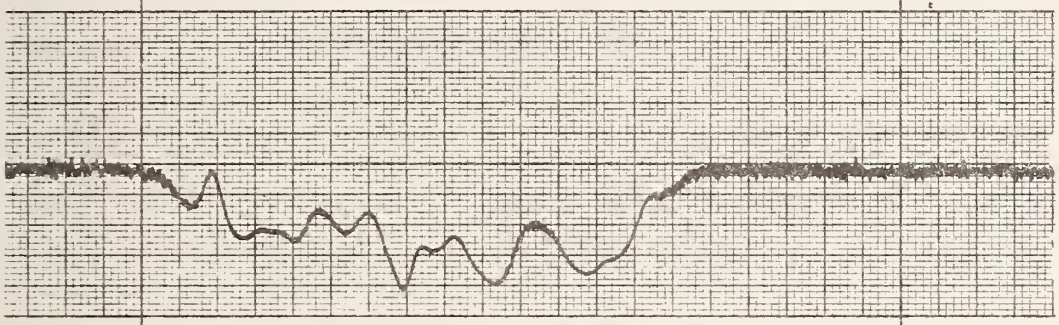

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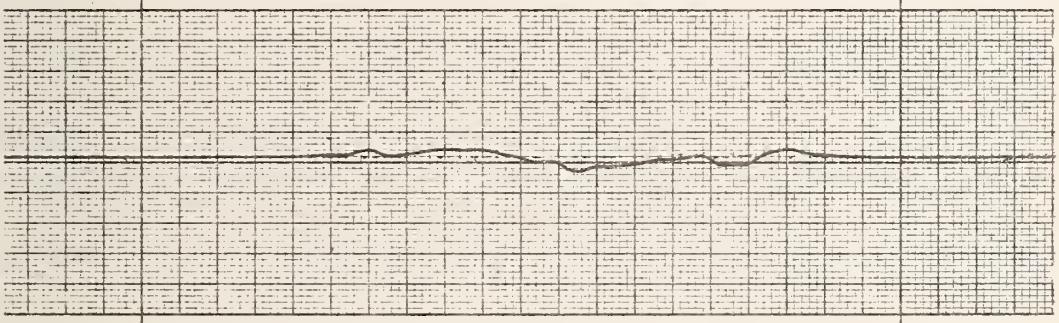
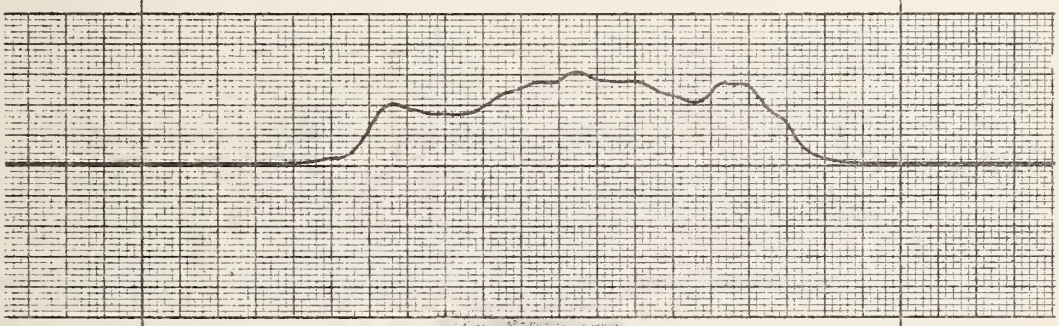
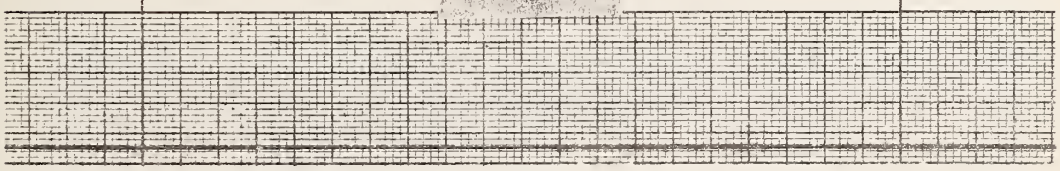
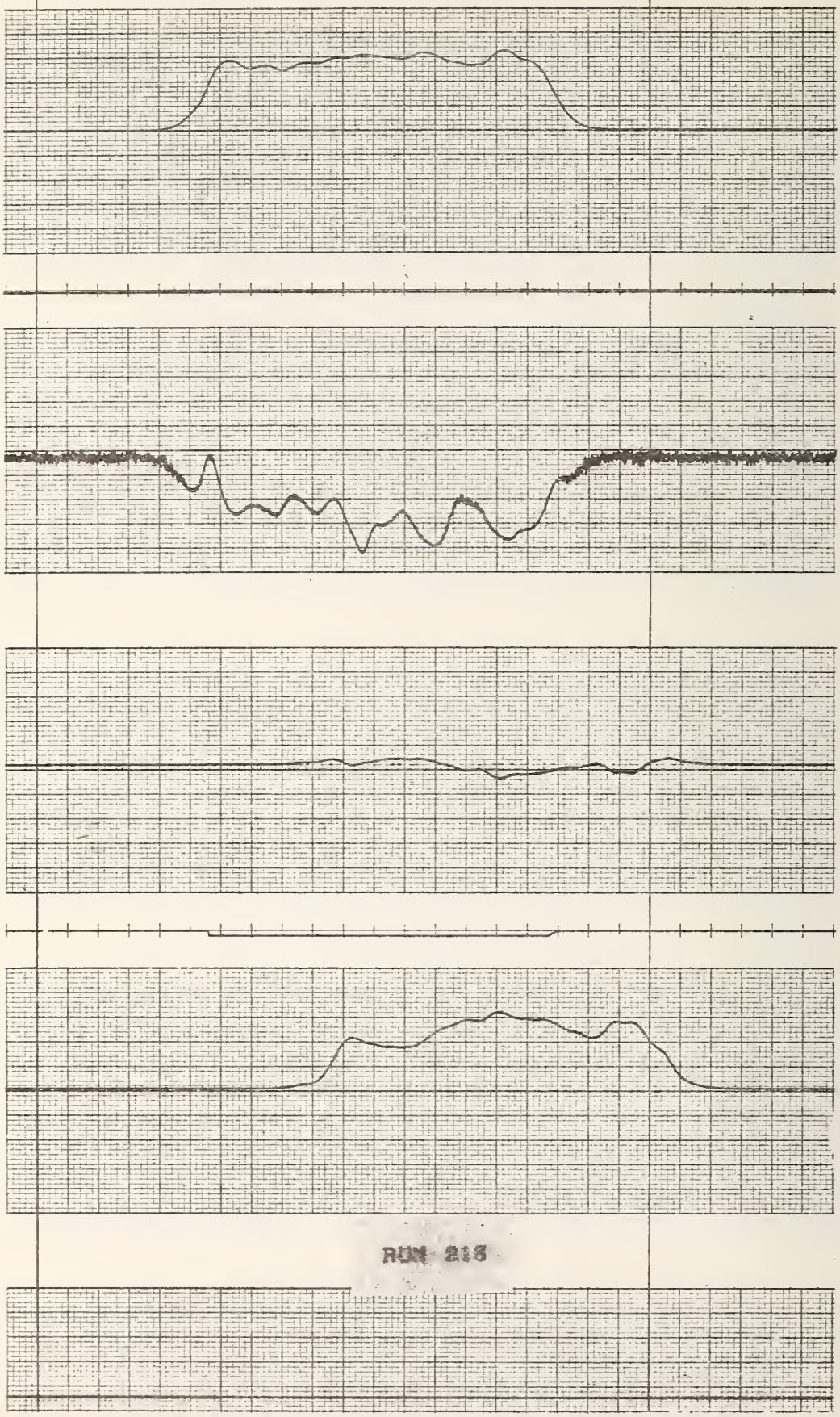




RUN 217

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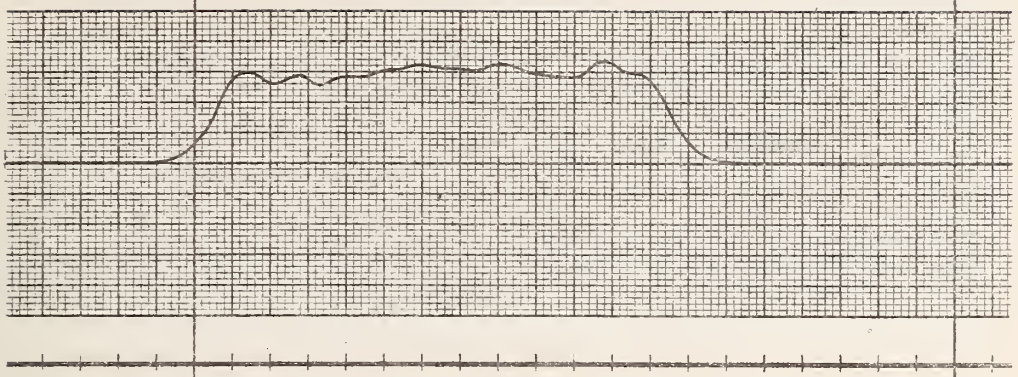

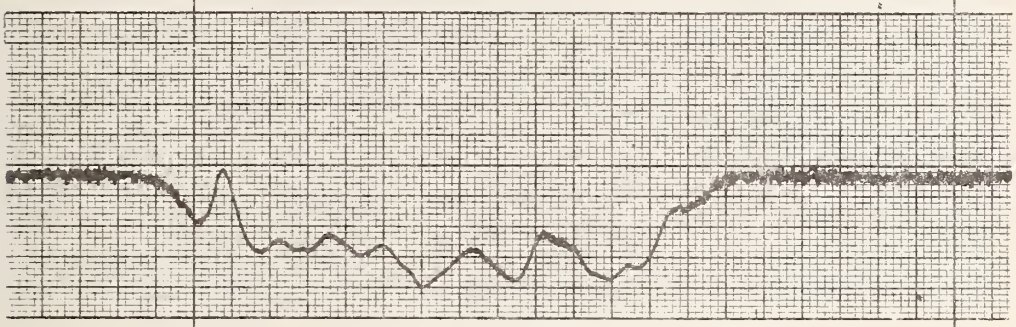

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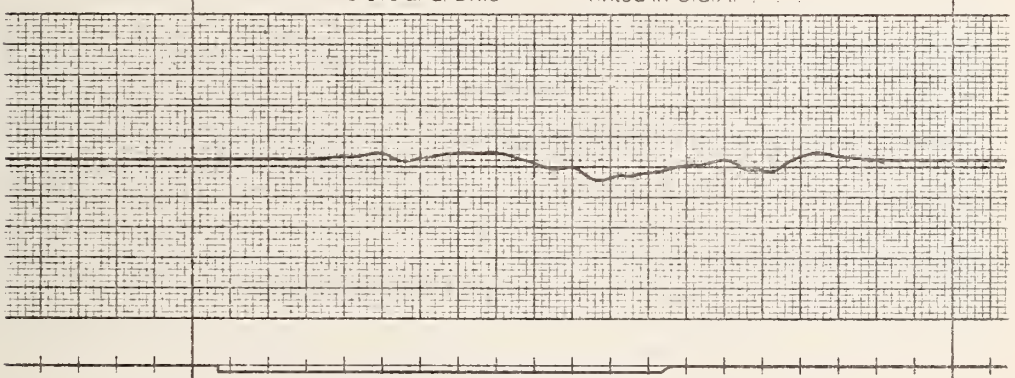

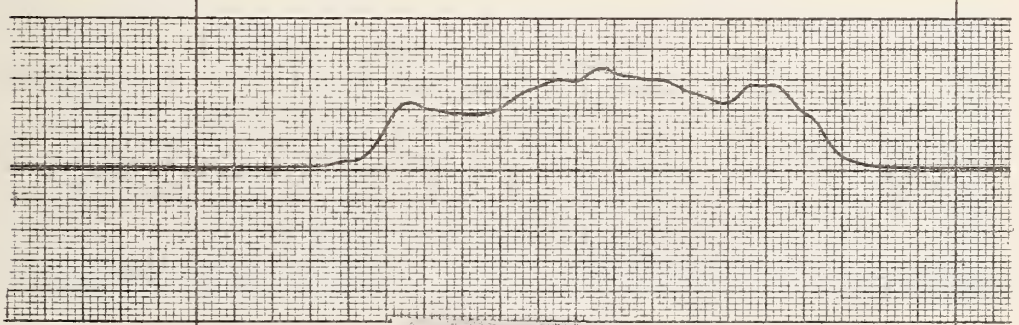

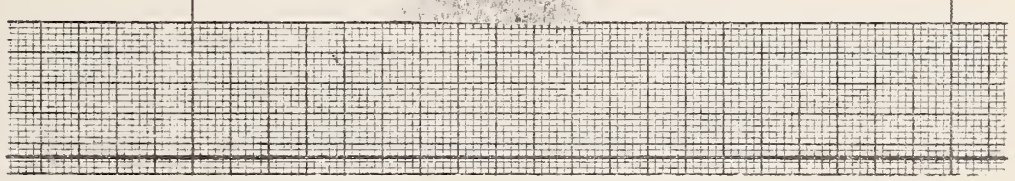

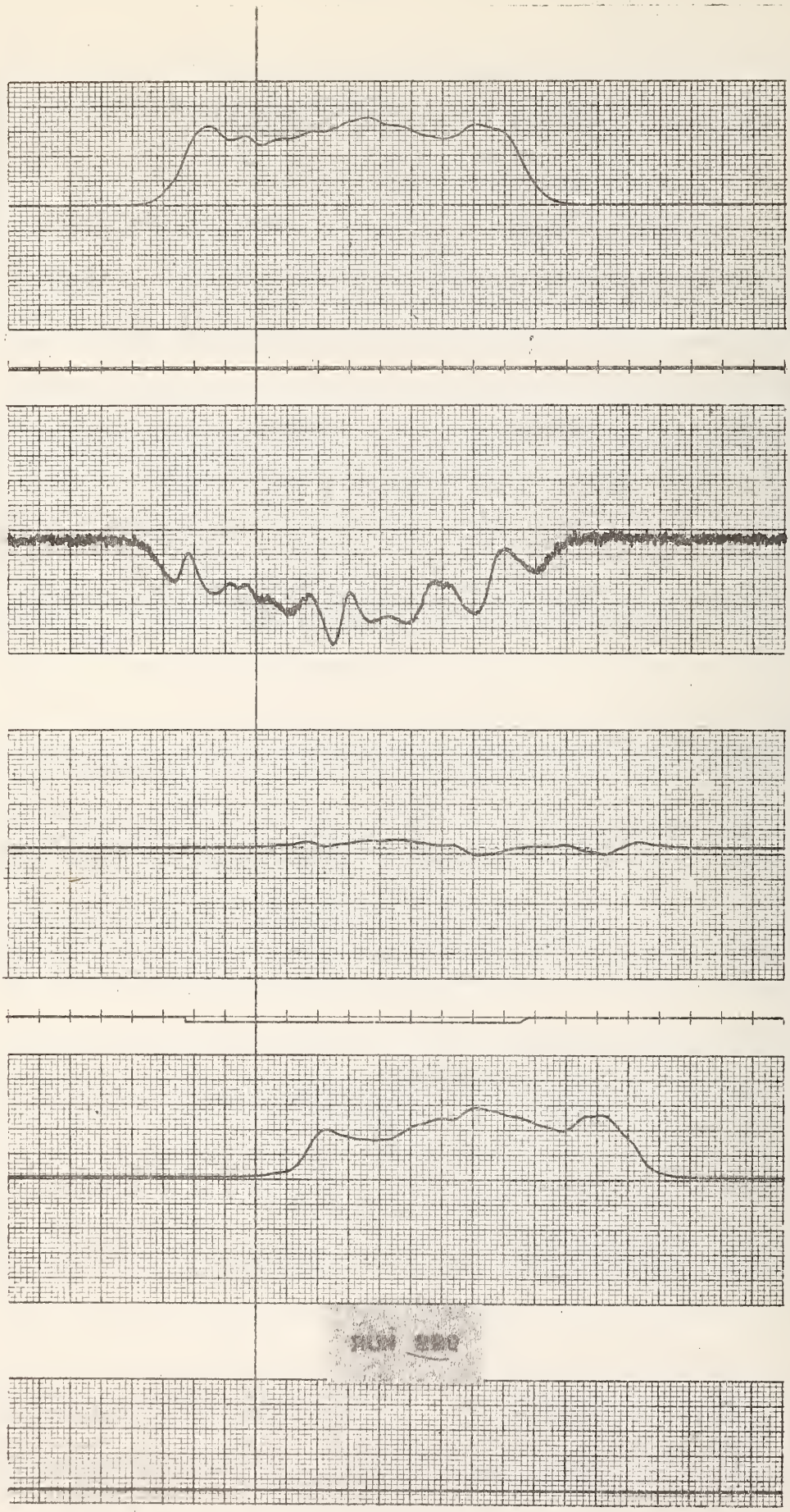

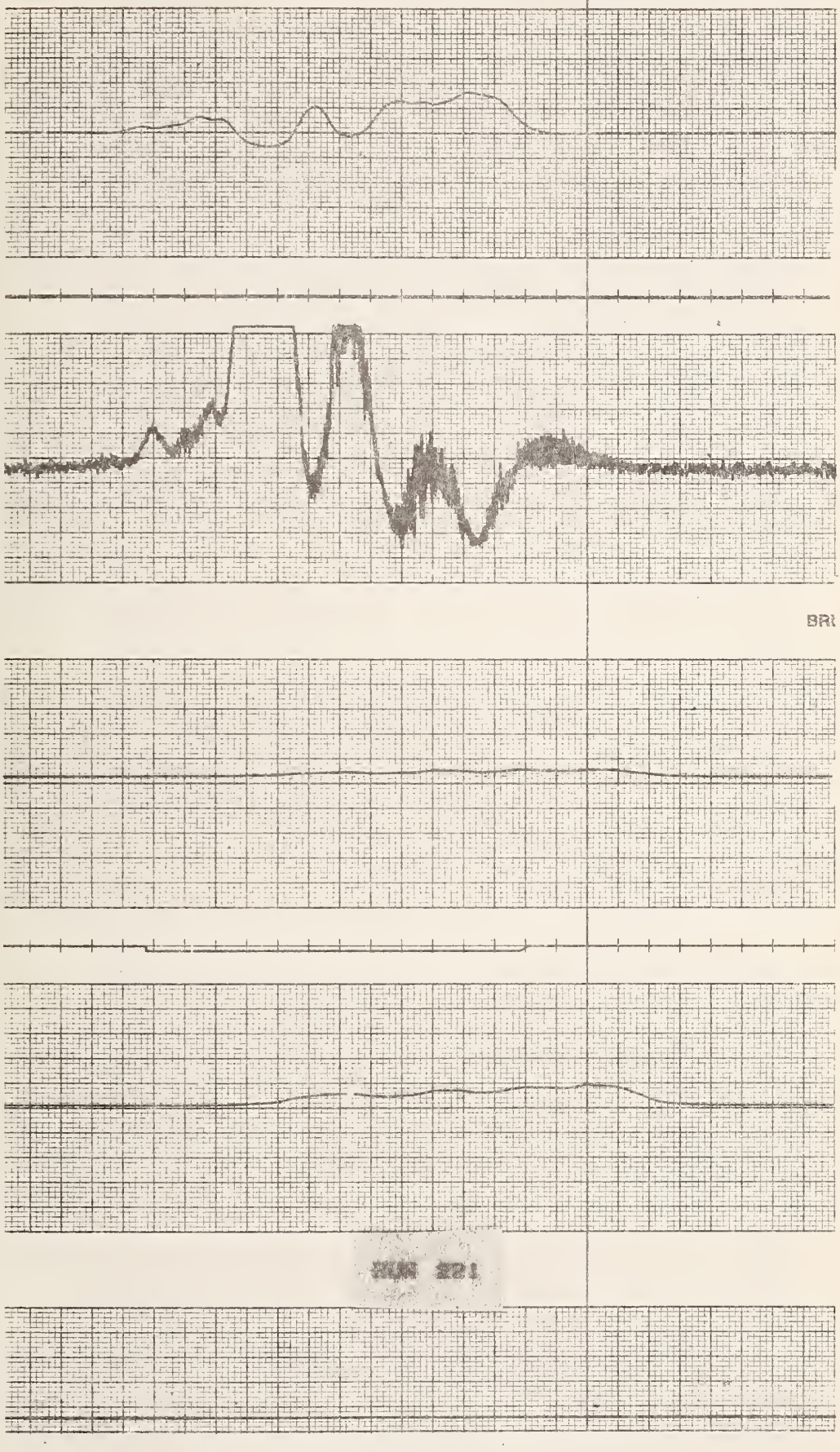
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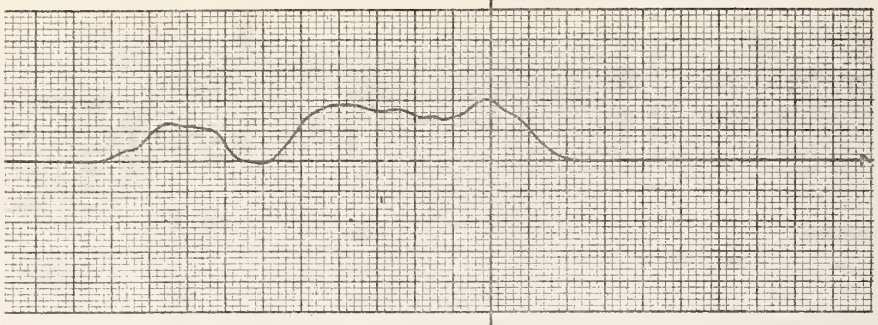

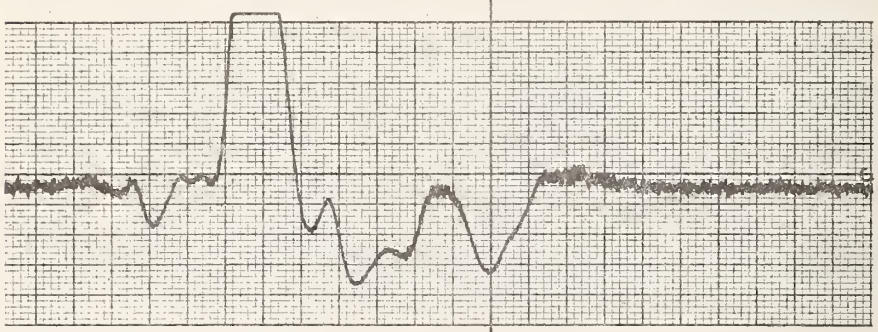

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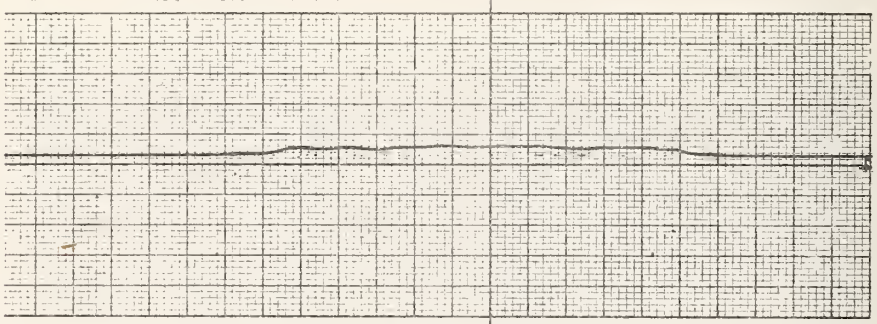
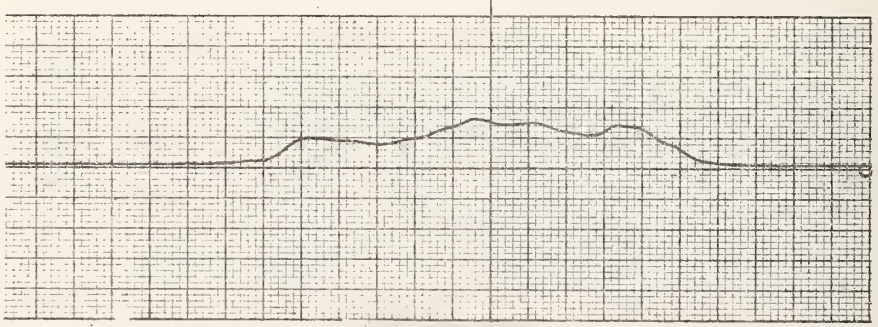
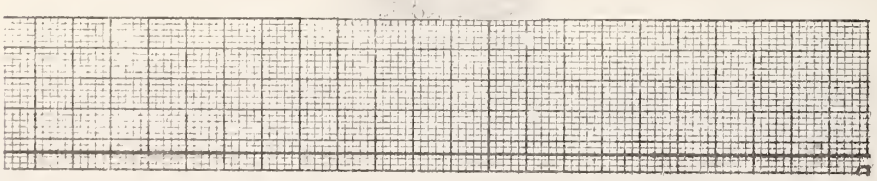
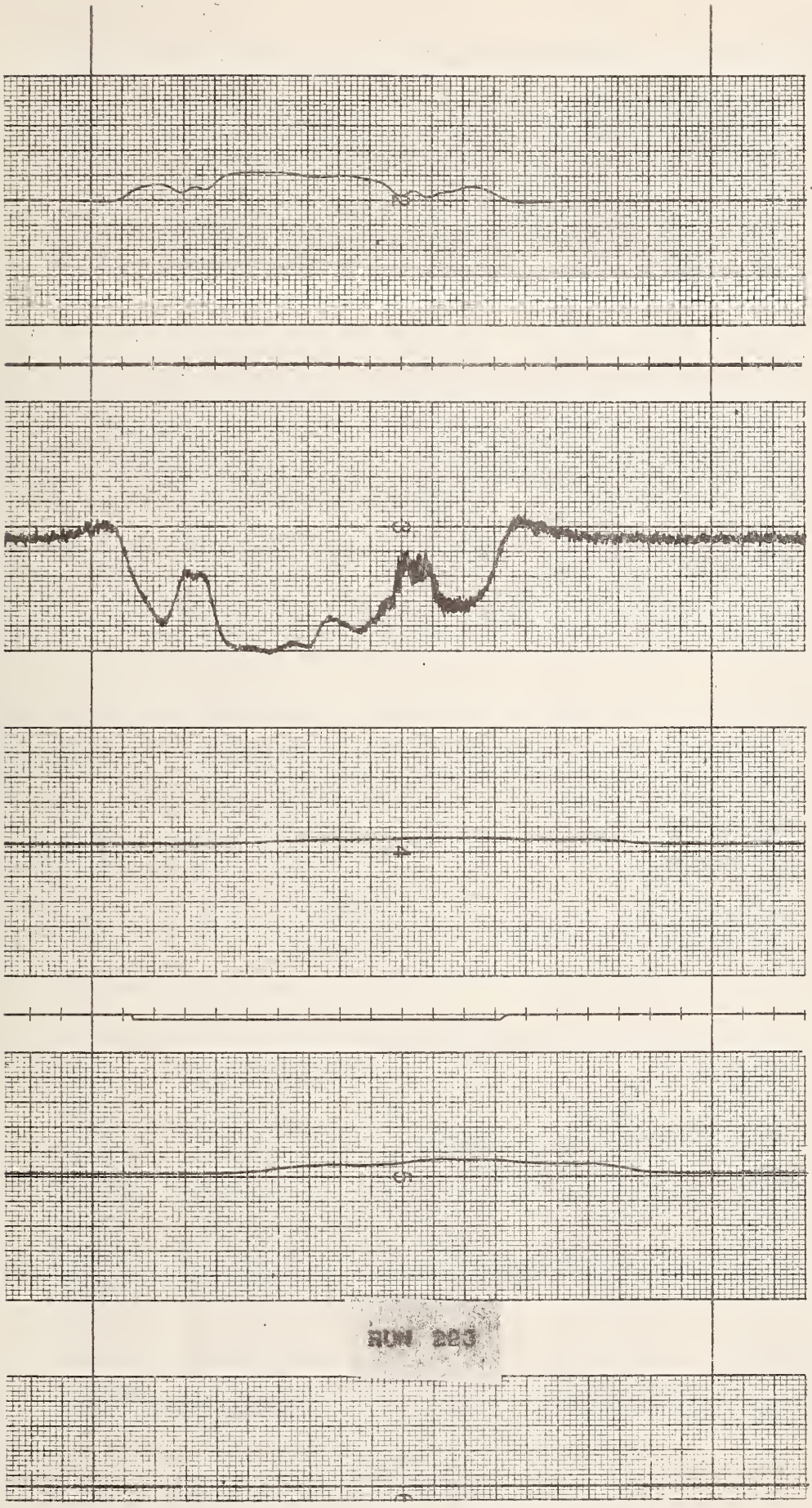
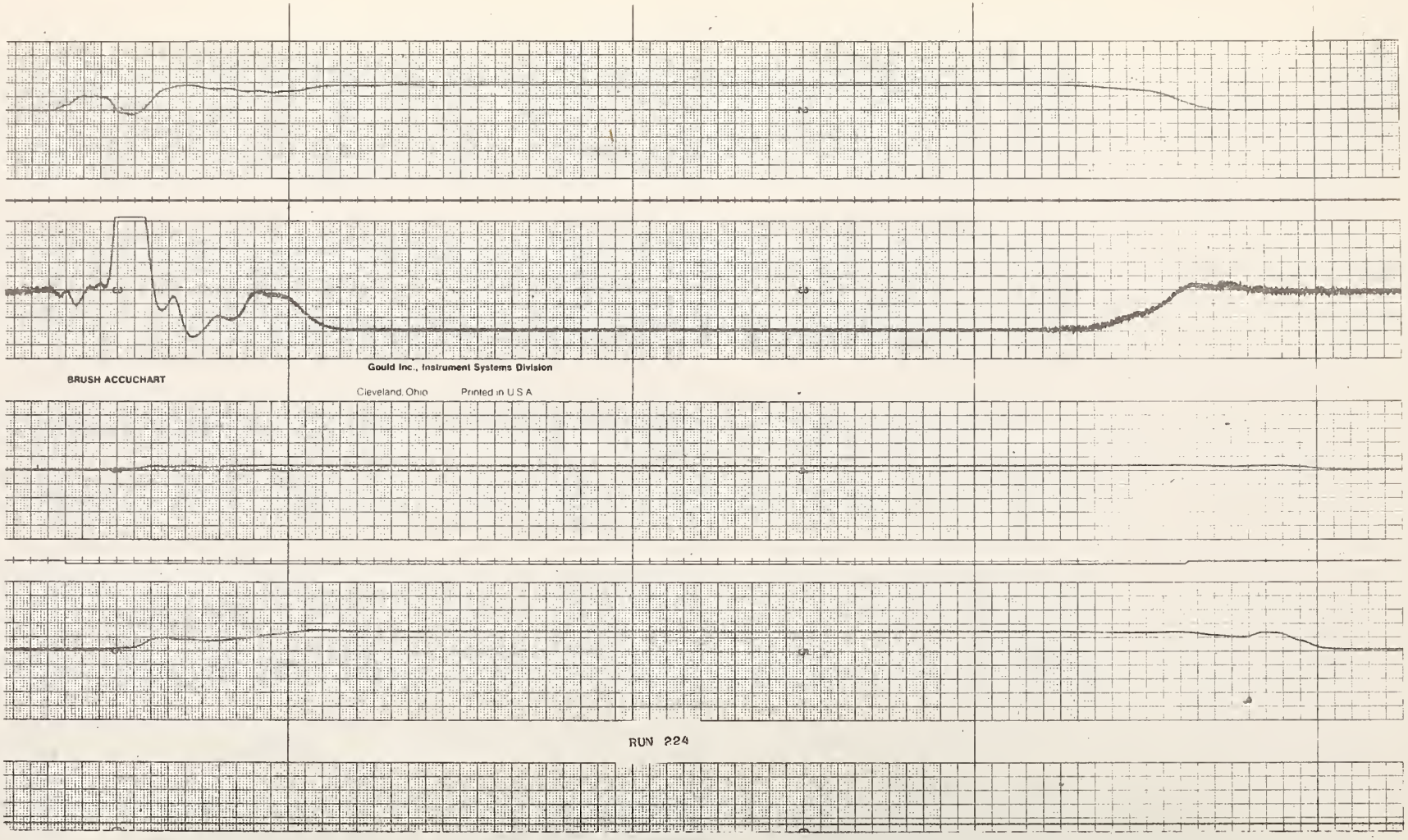




RUN 322




RUN 223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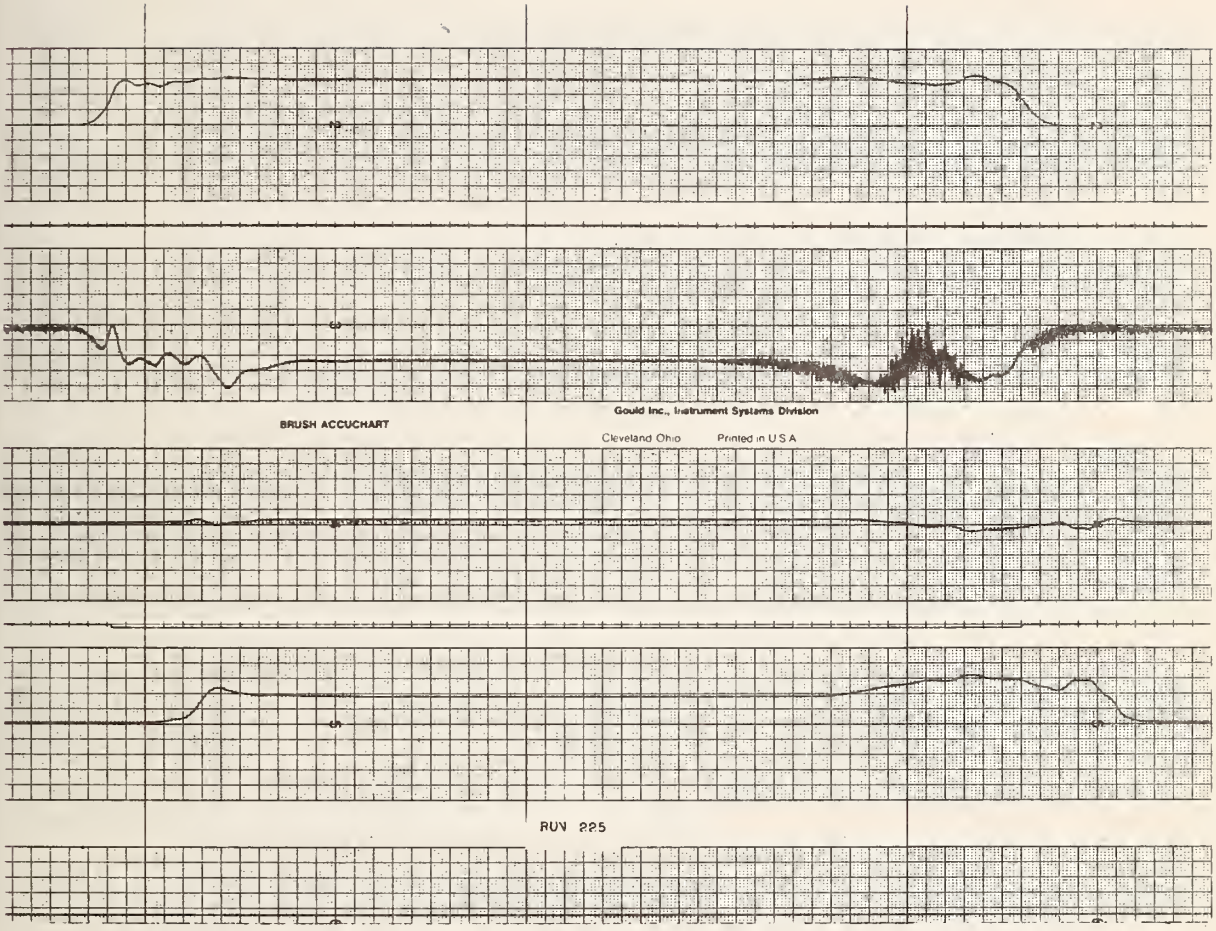
RUN 224


BRUSH ACCUCHART
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in U.S.A.
RUN 225

Runs 226-229

No Strip Recordings
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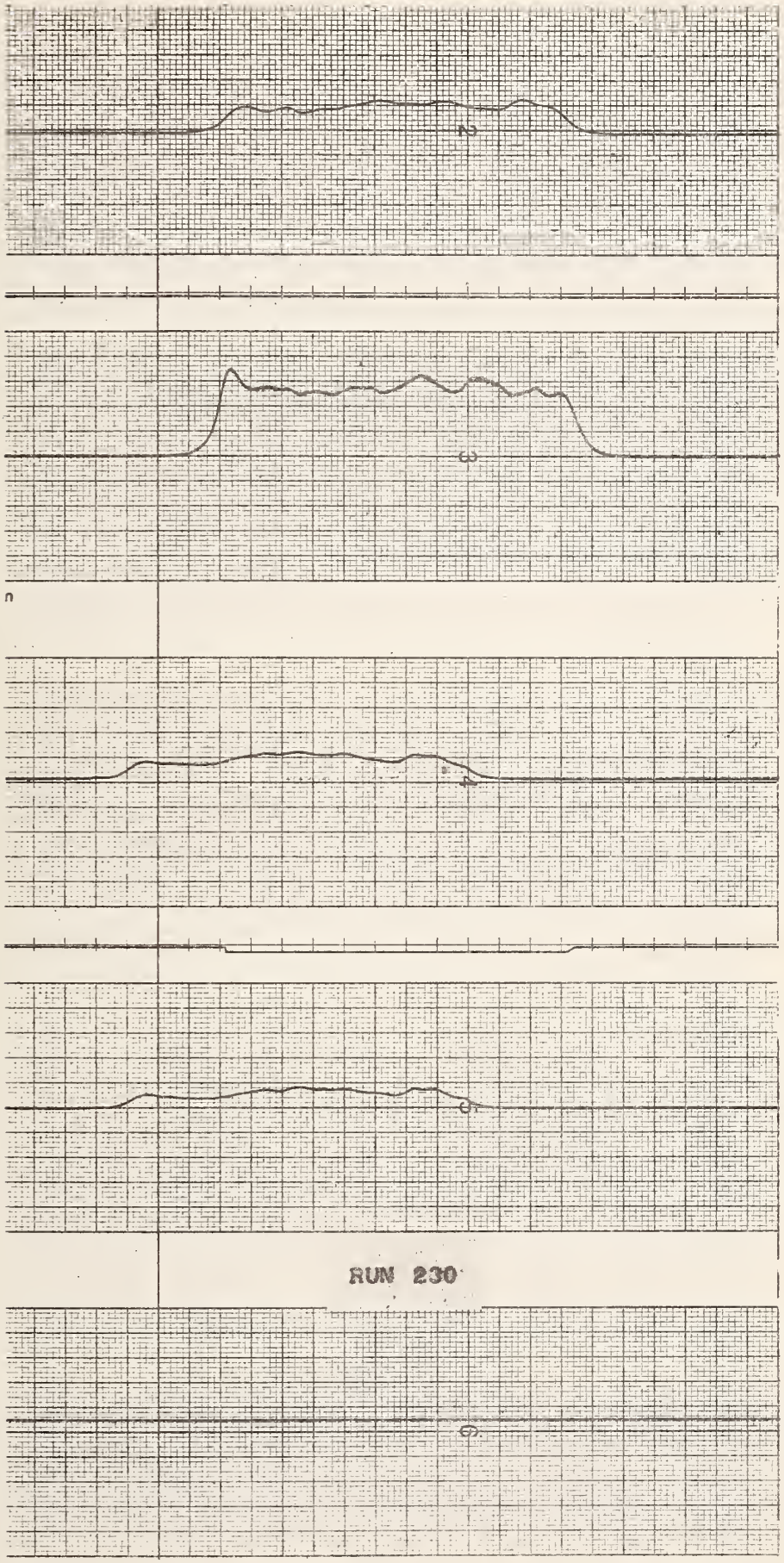
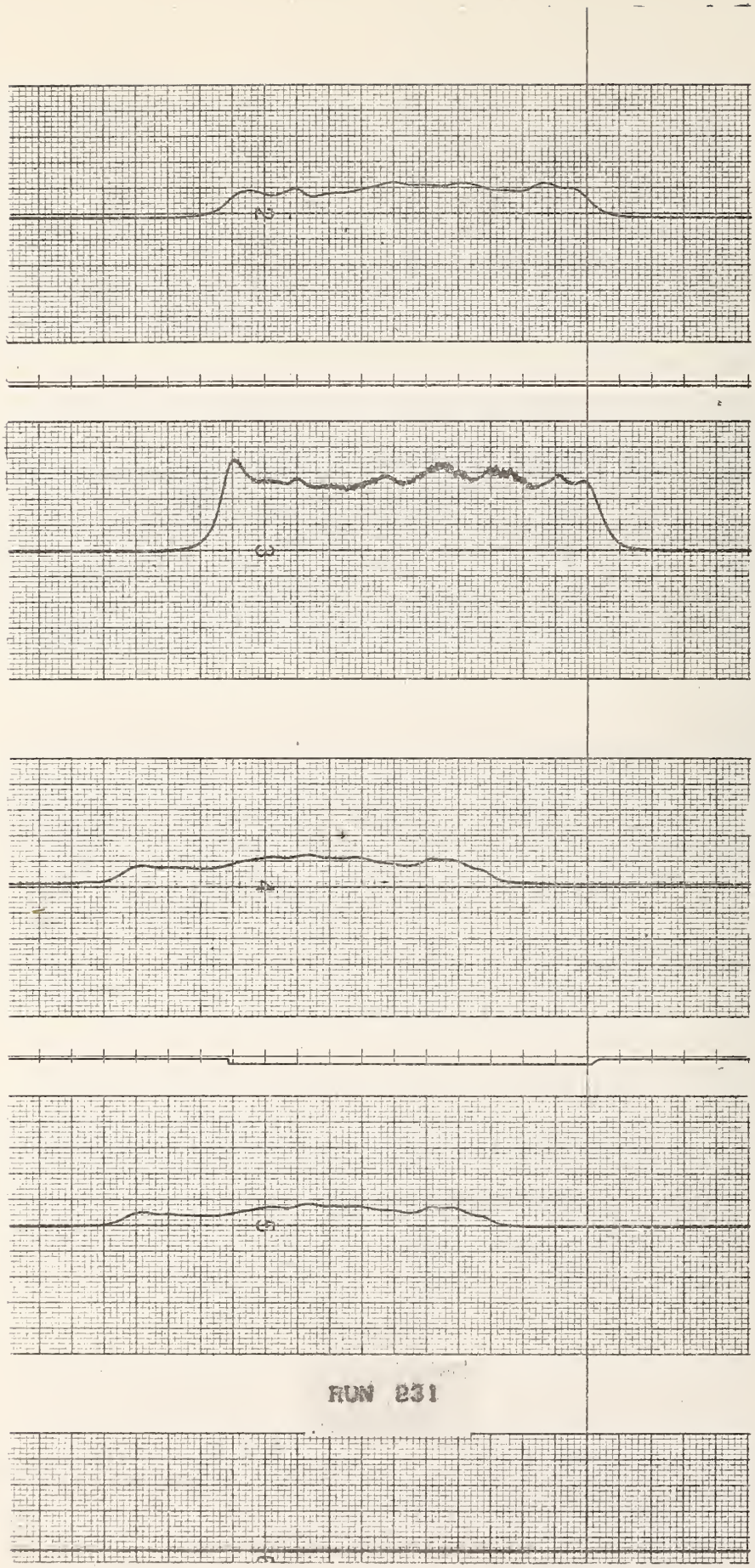

RUN 230



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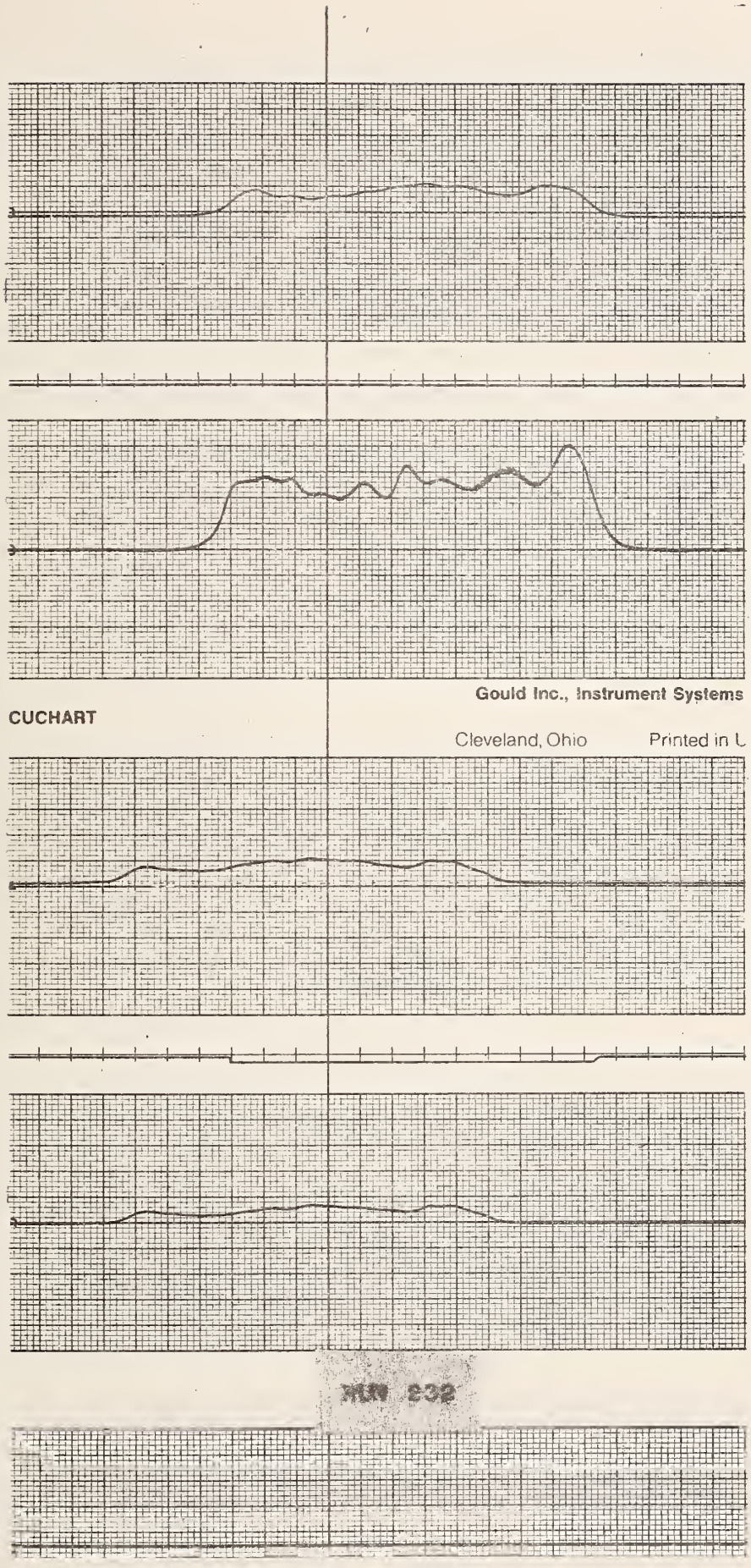
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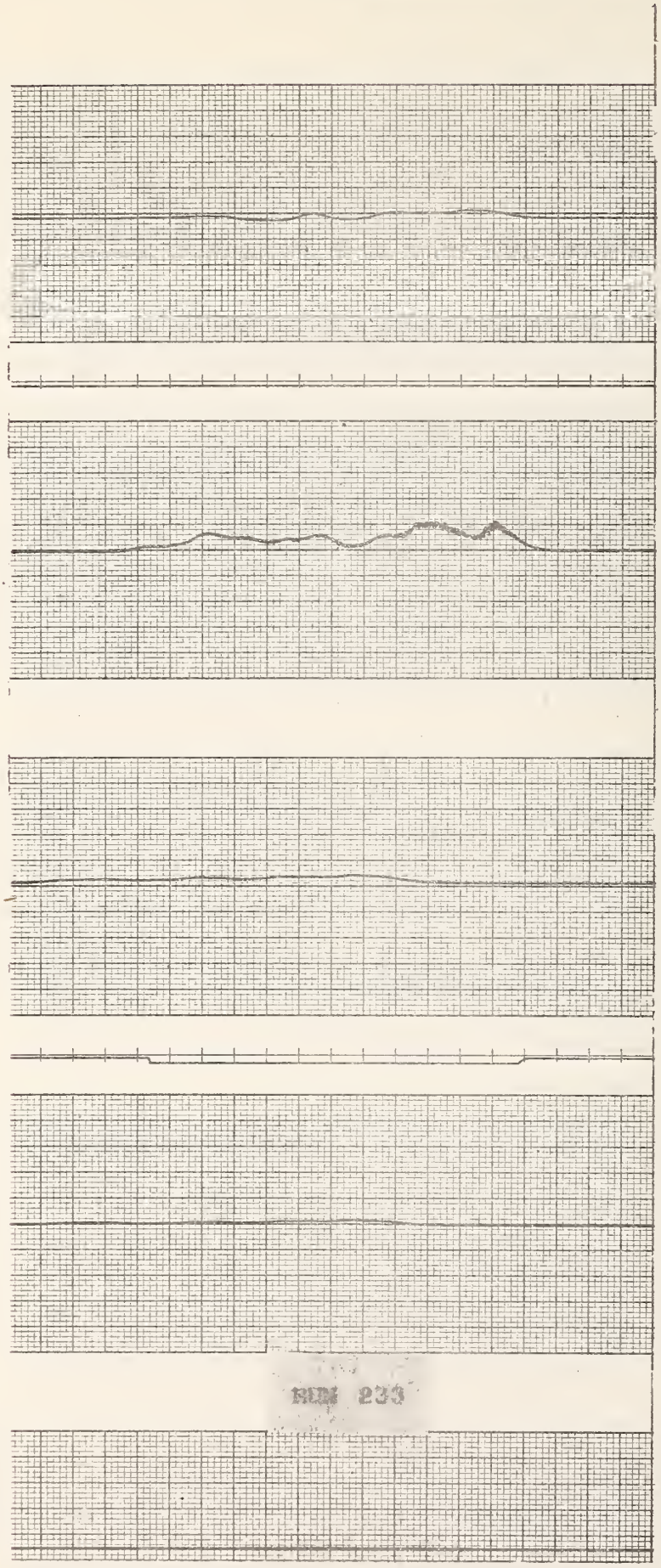

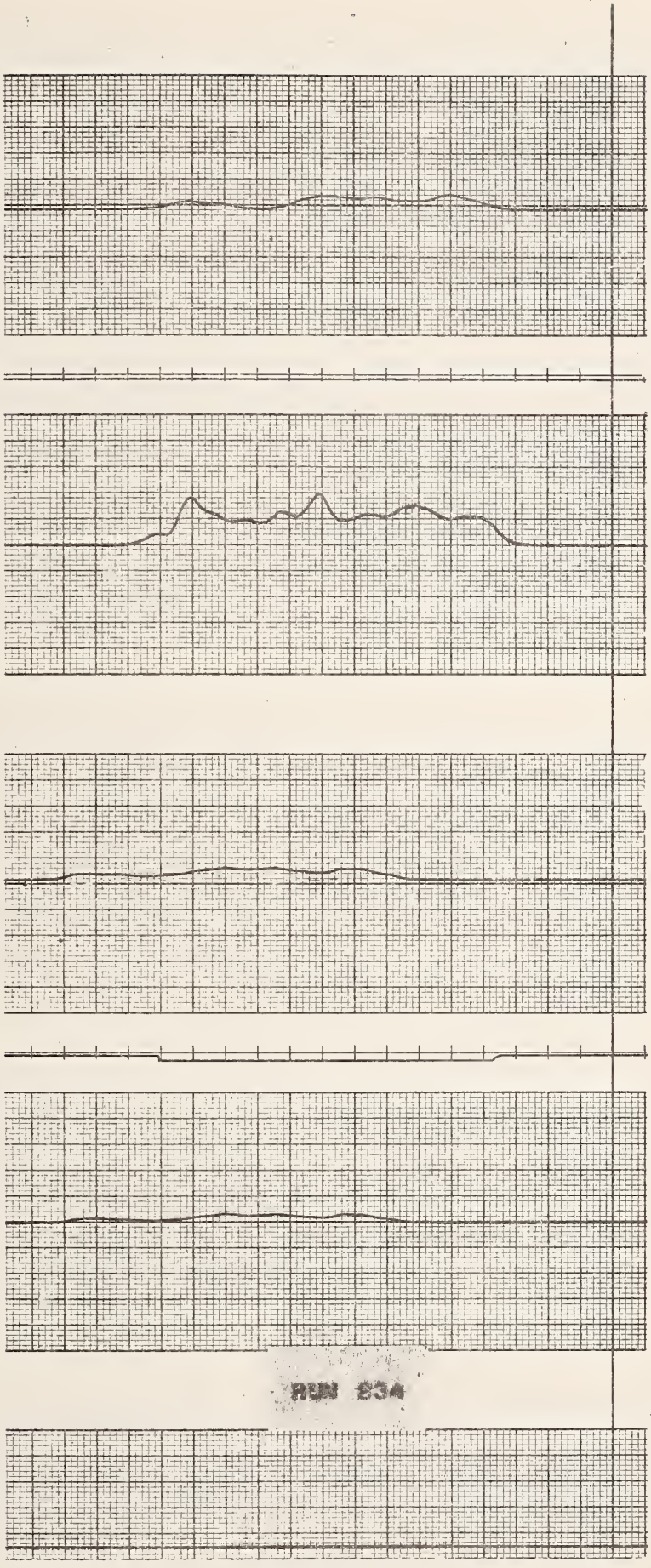
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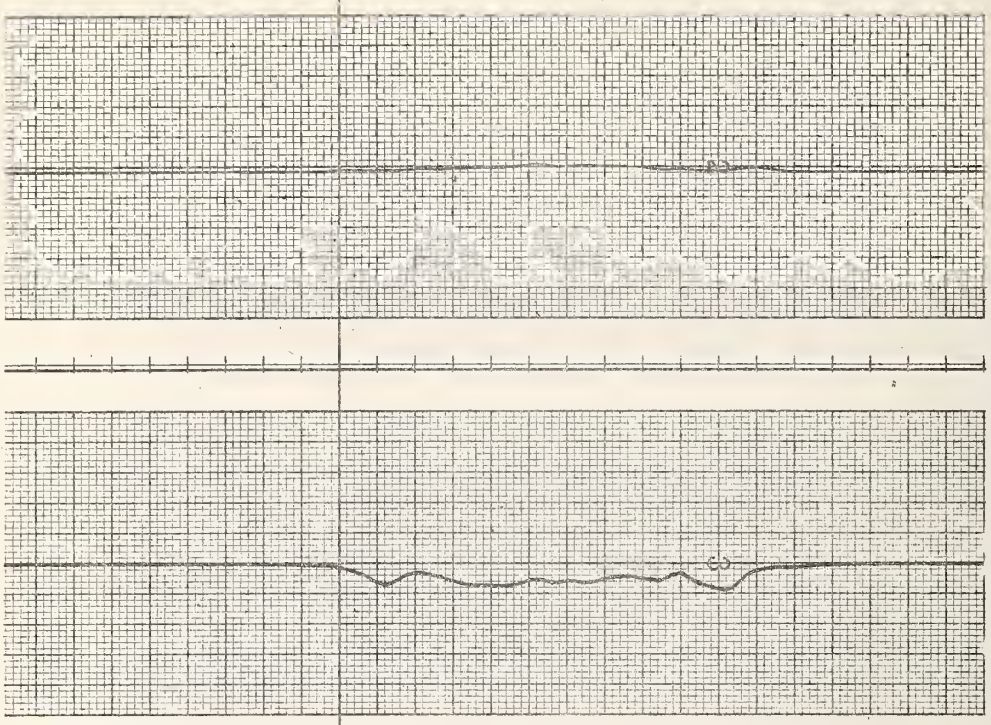

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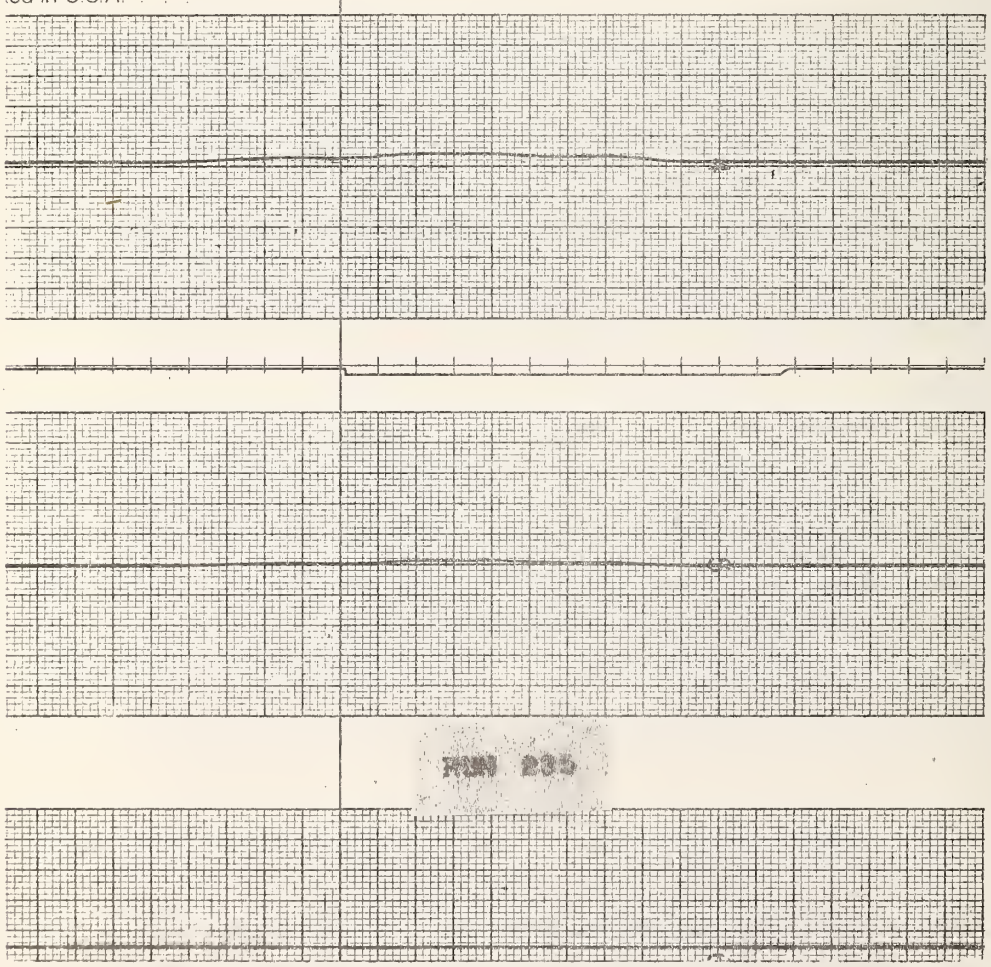
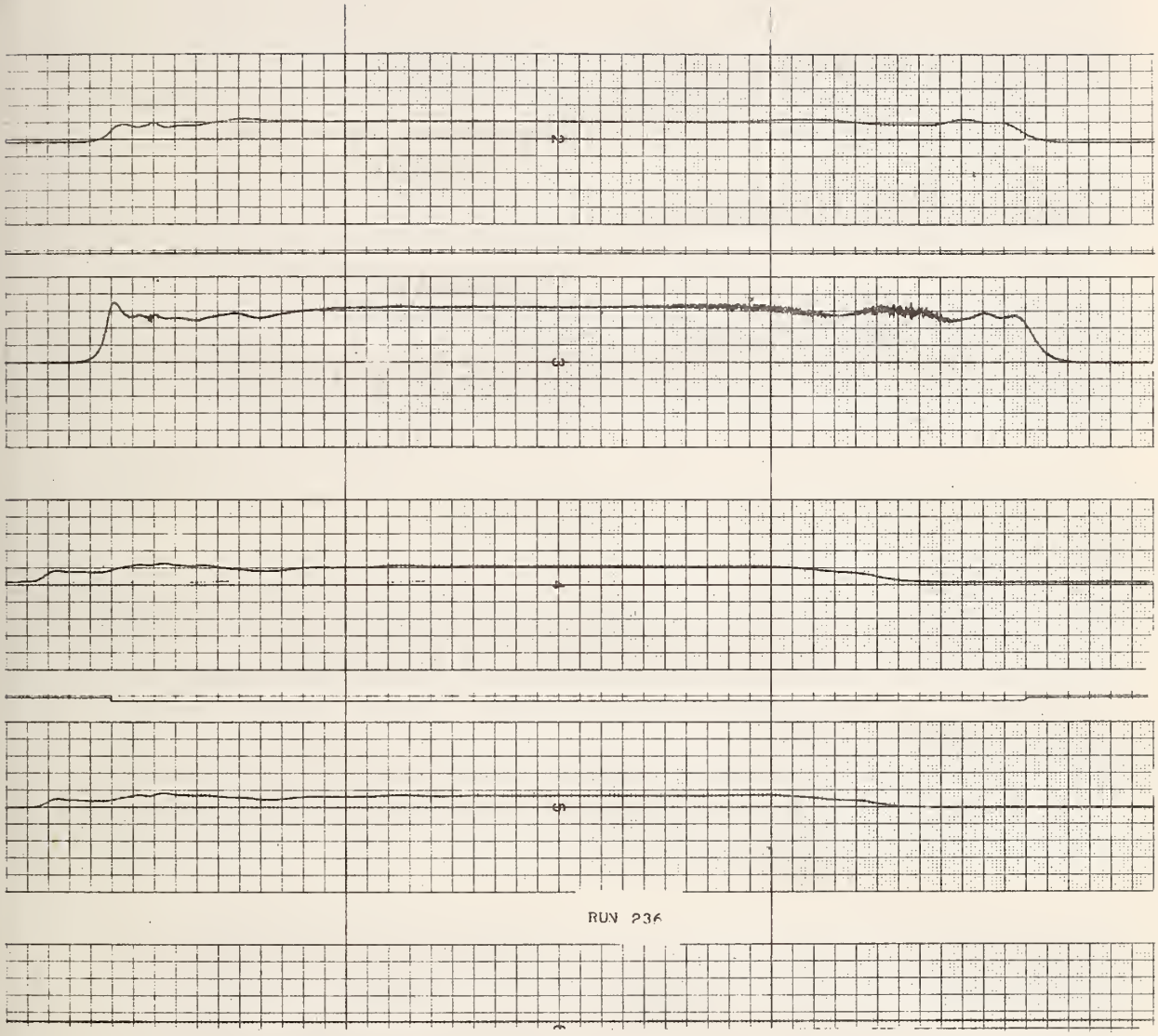
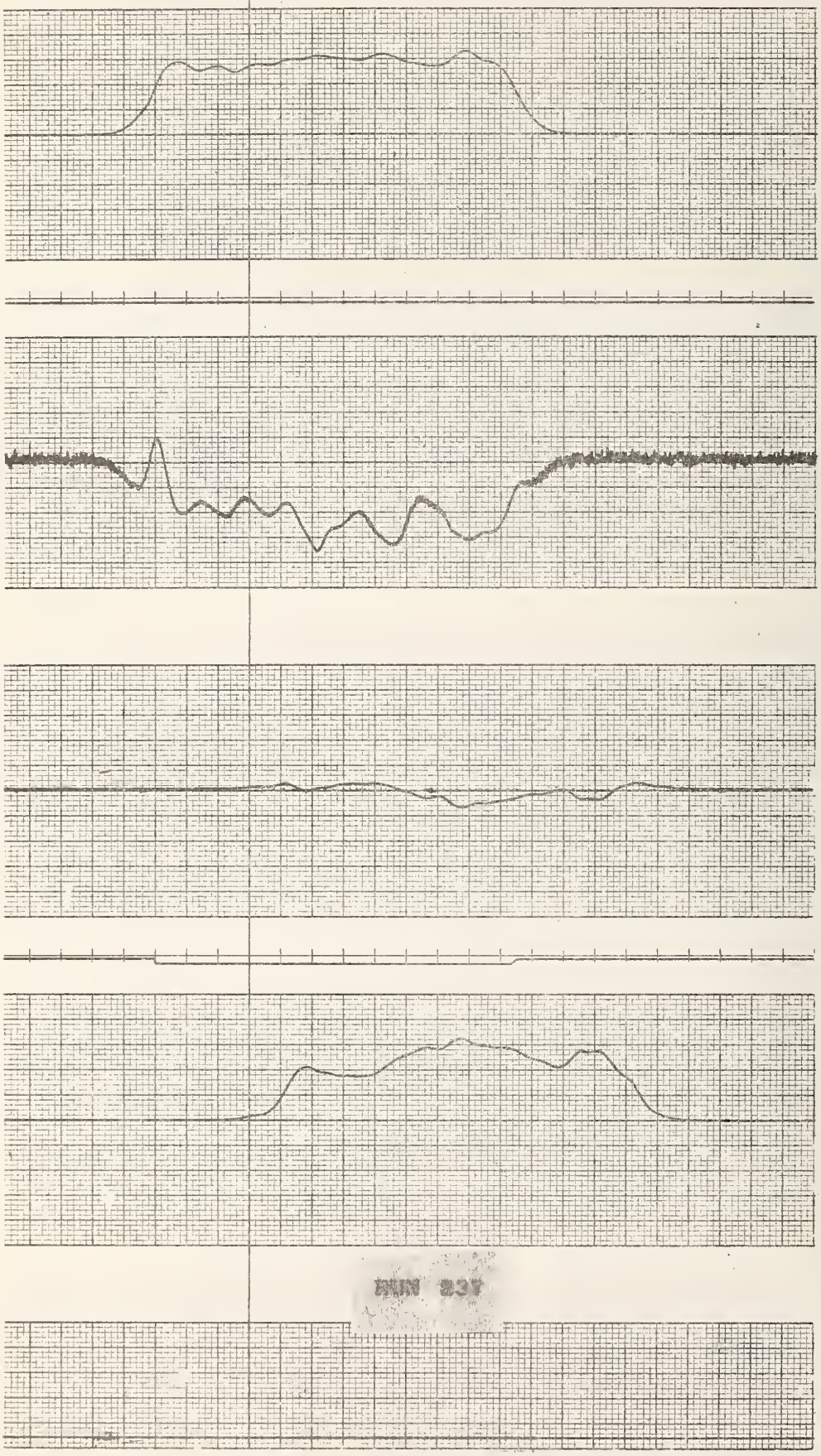
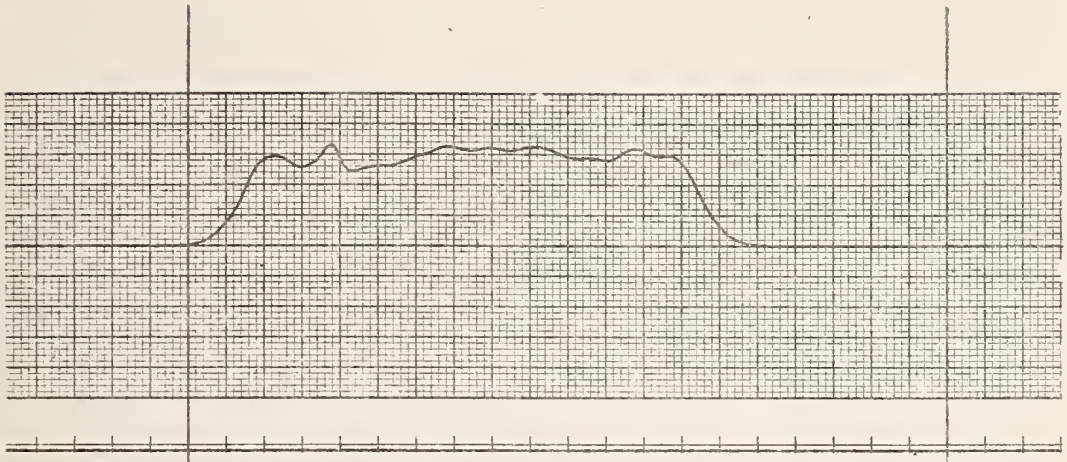
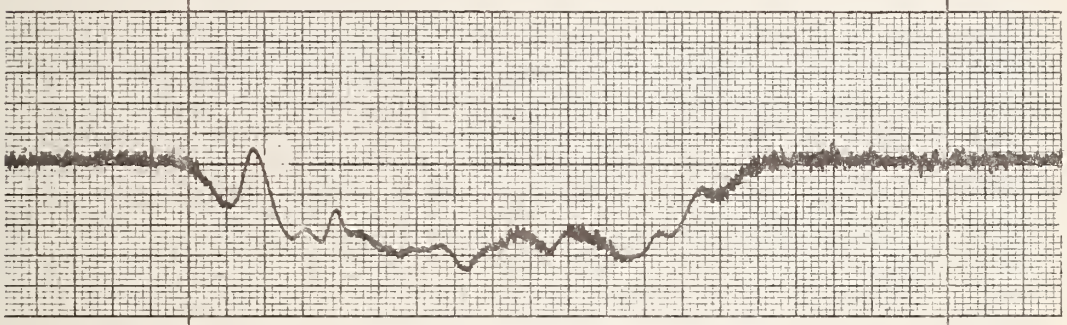



RUN 236







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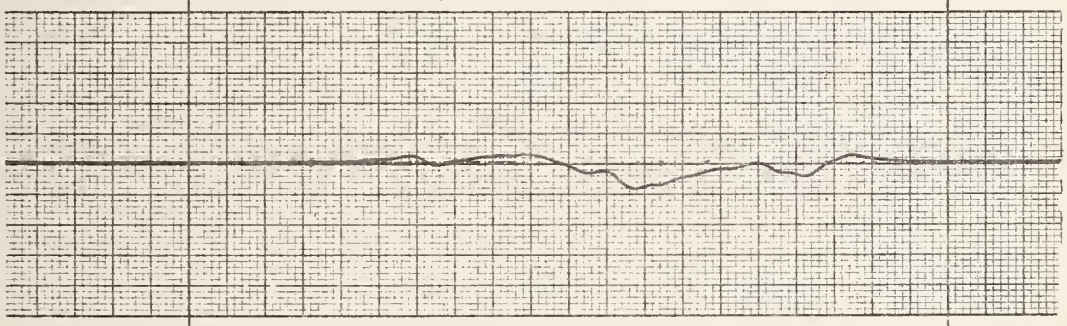

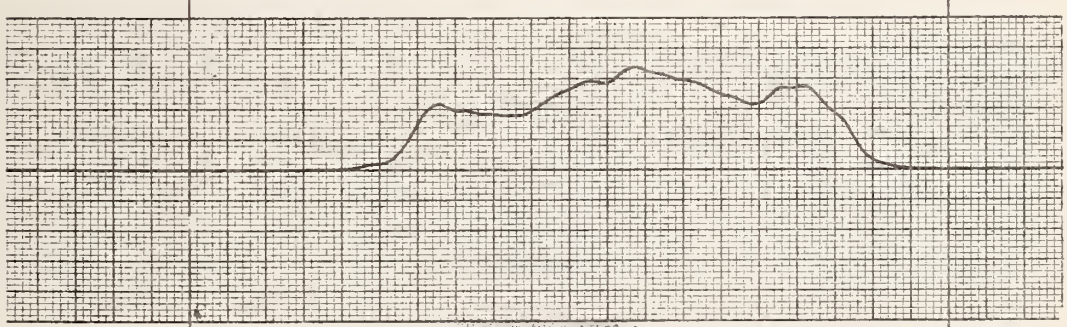

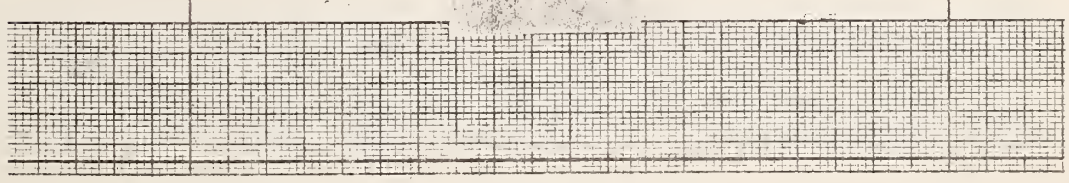

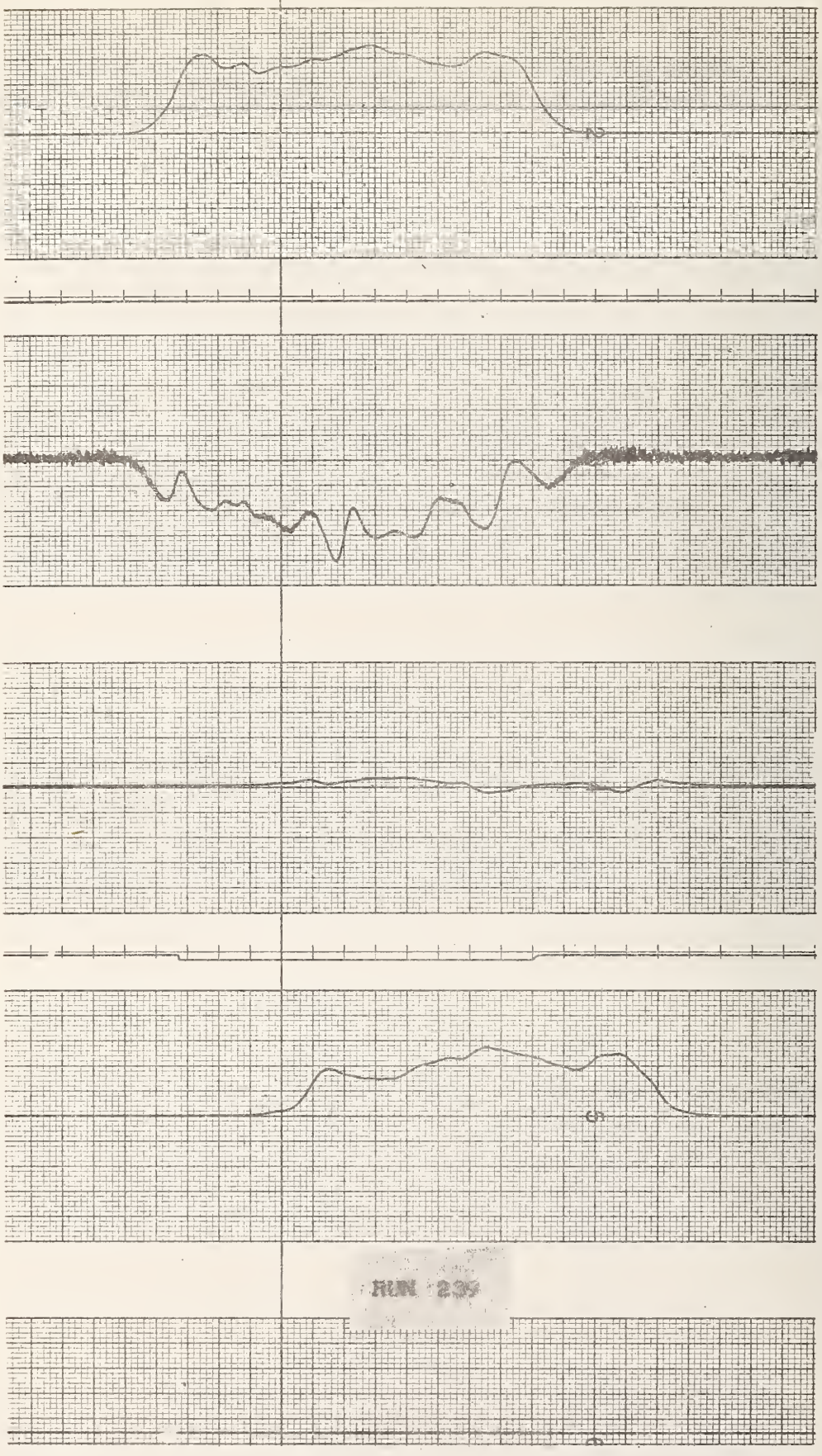

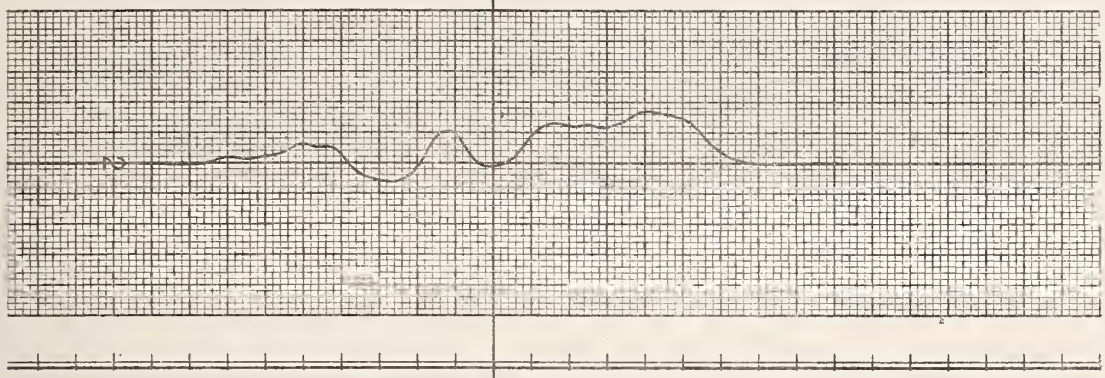

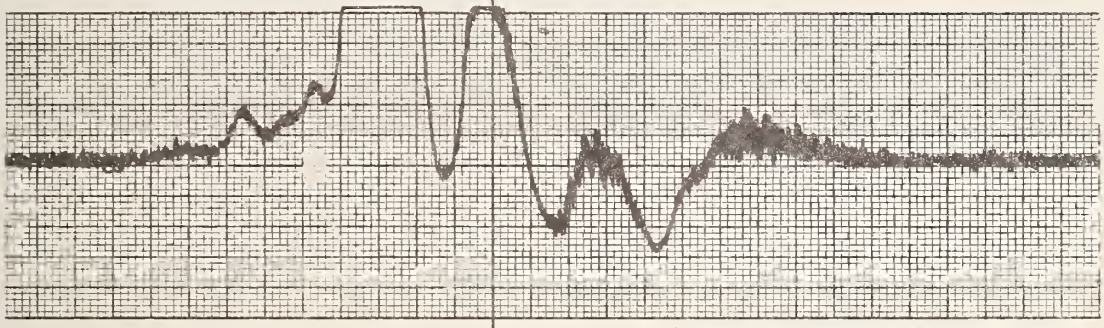

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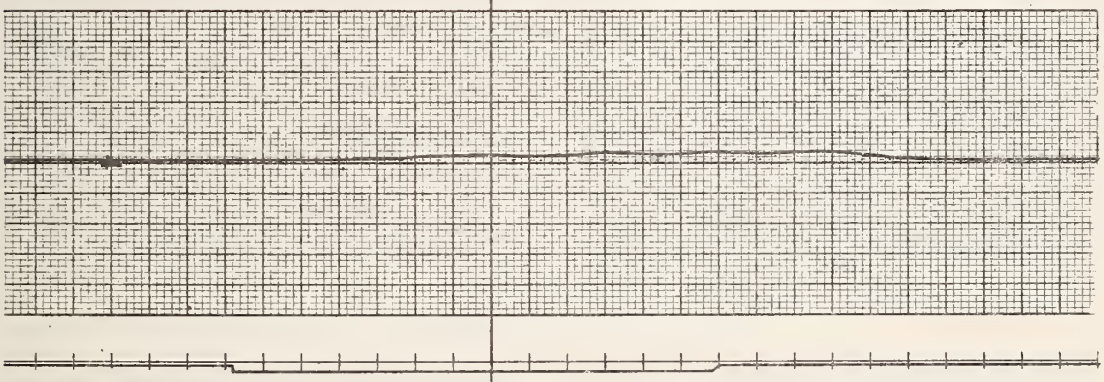
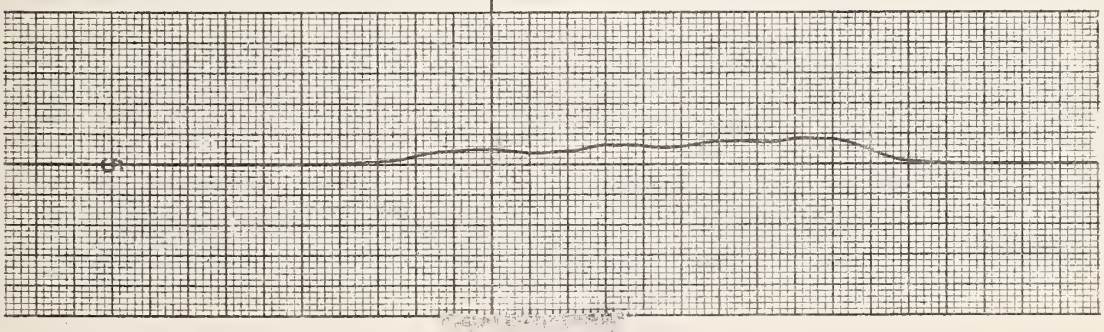
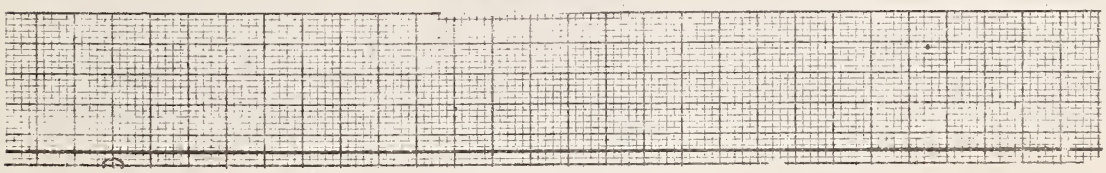
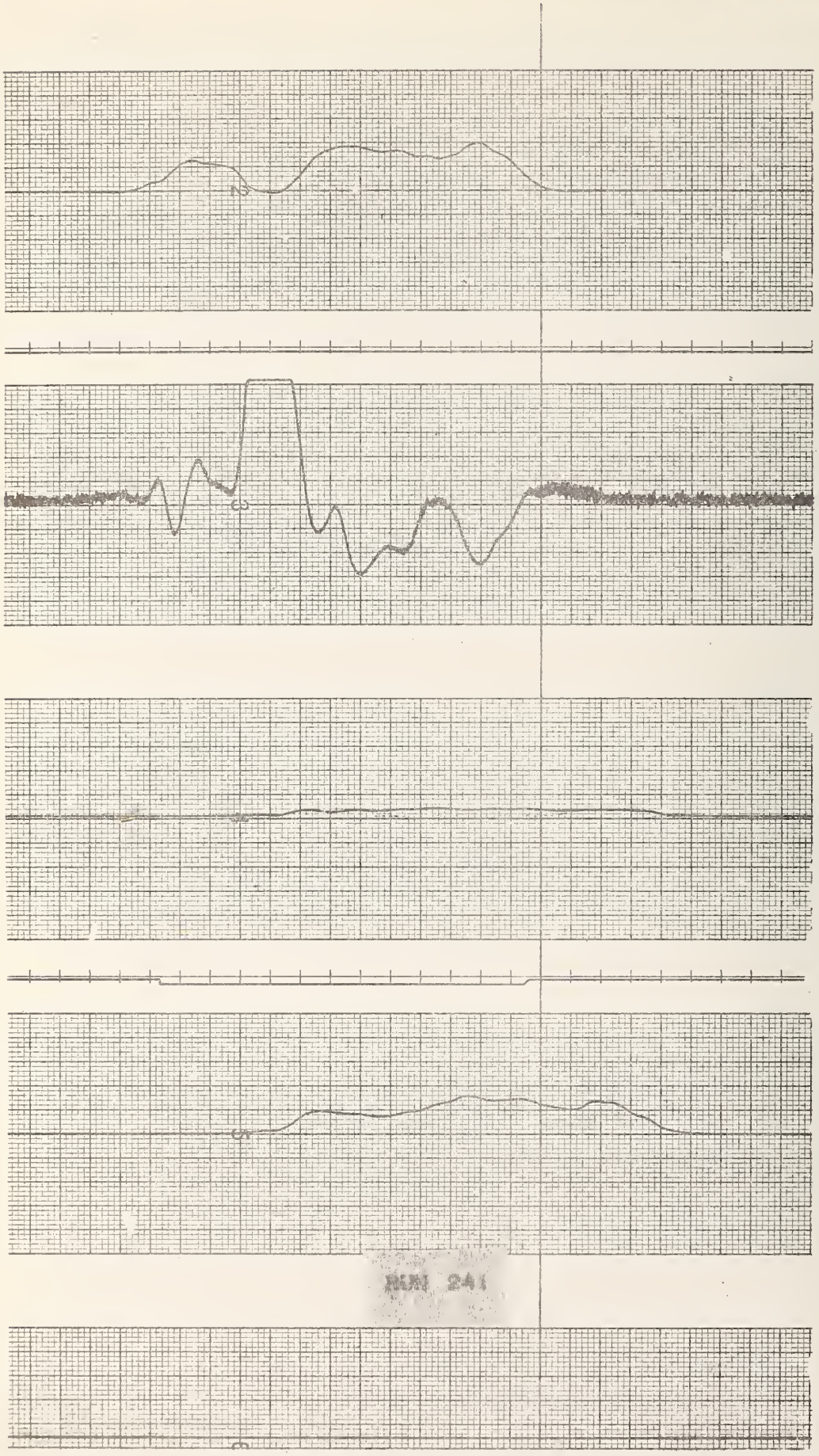
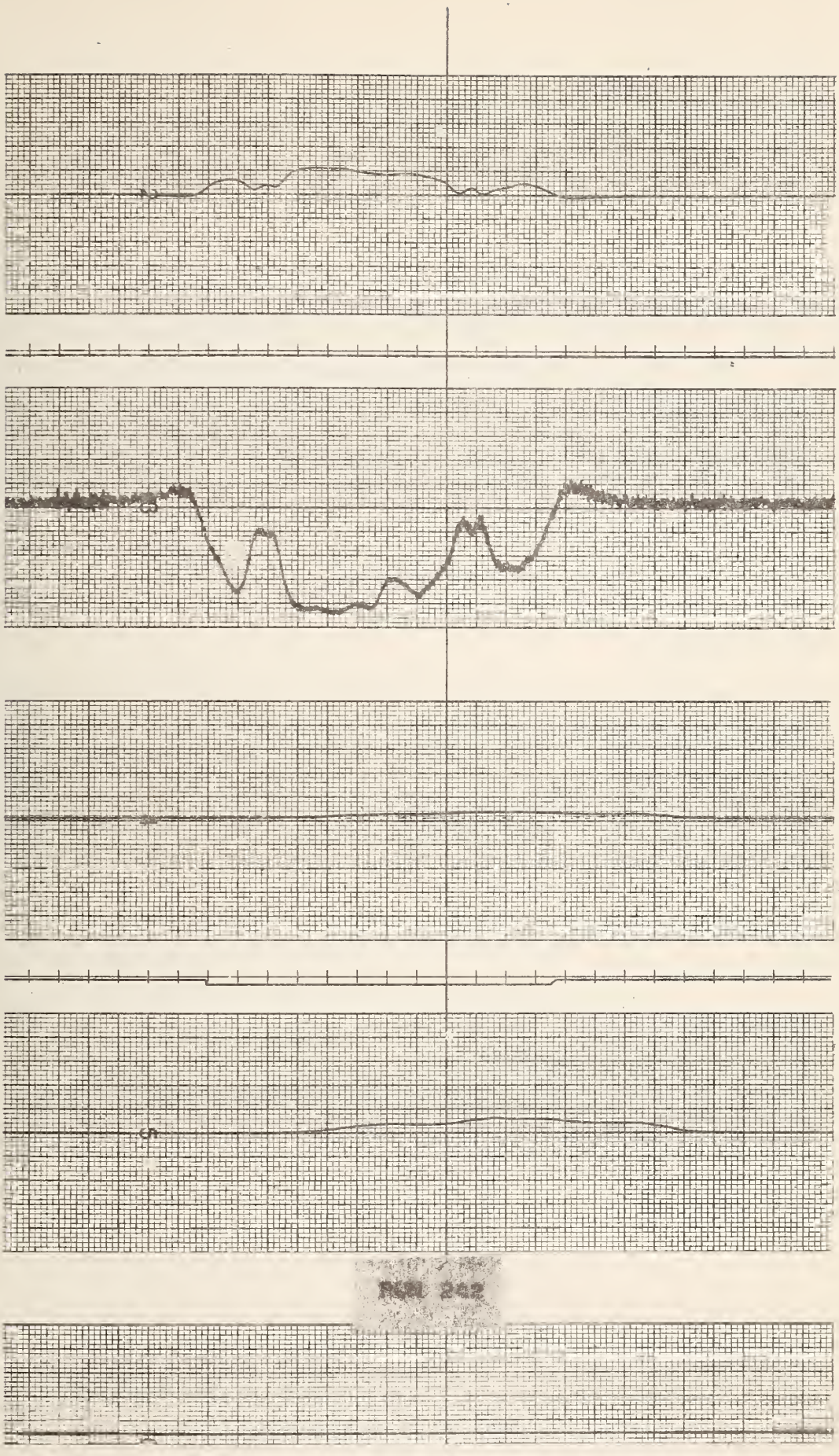


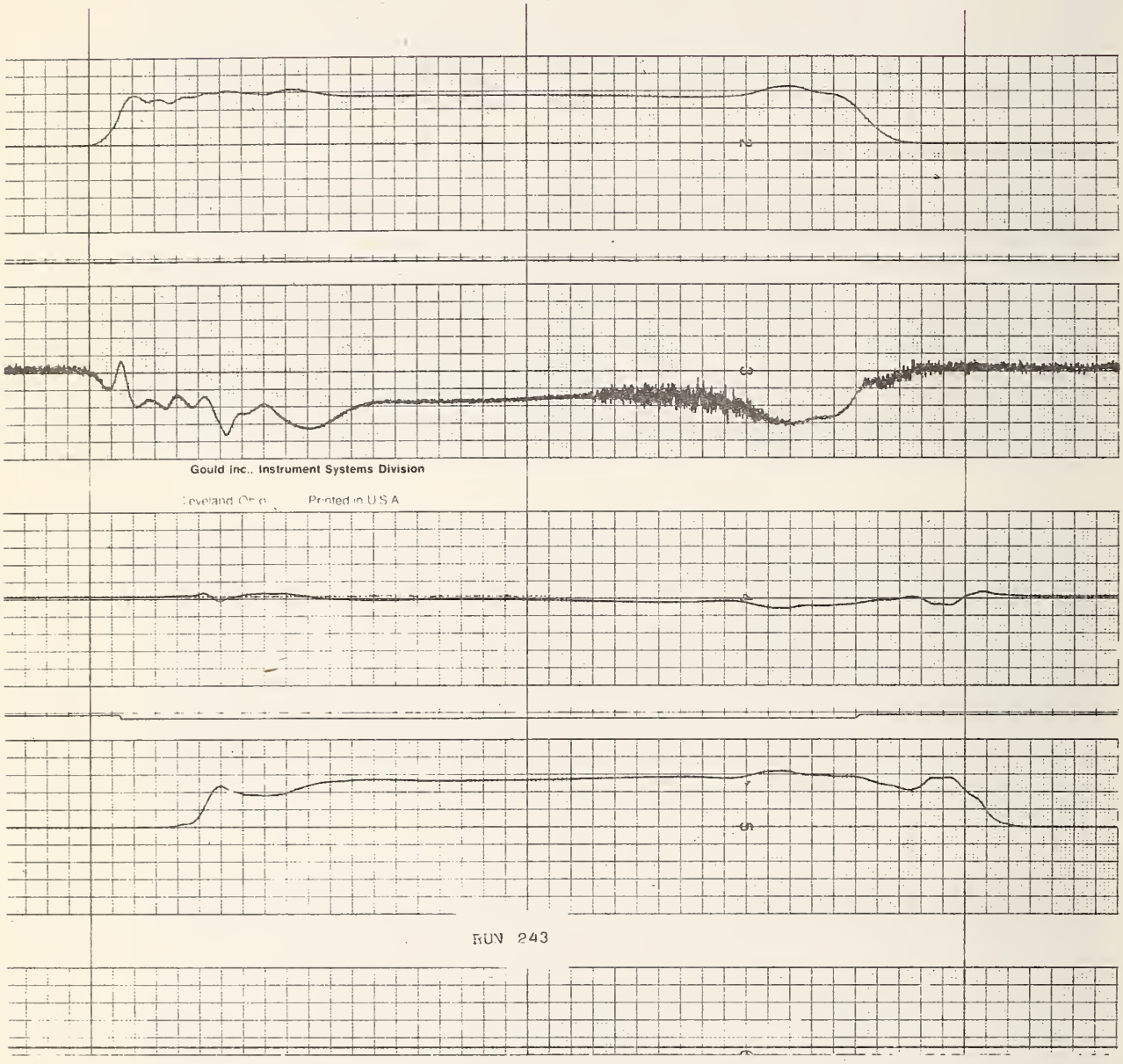


RUN 240








Gould inc., Instrument Systems Division
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RUN 243

Runs 244-245

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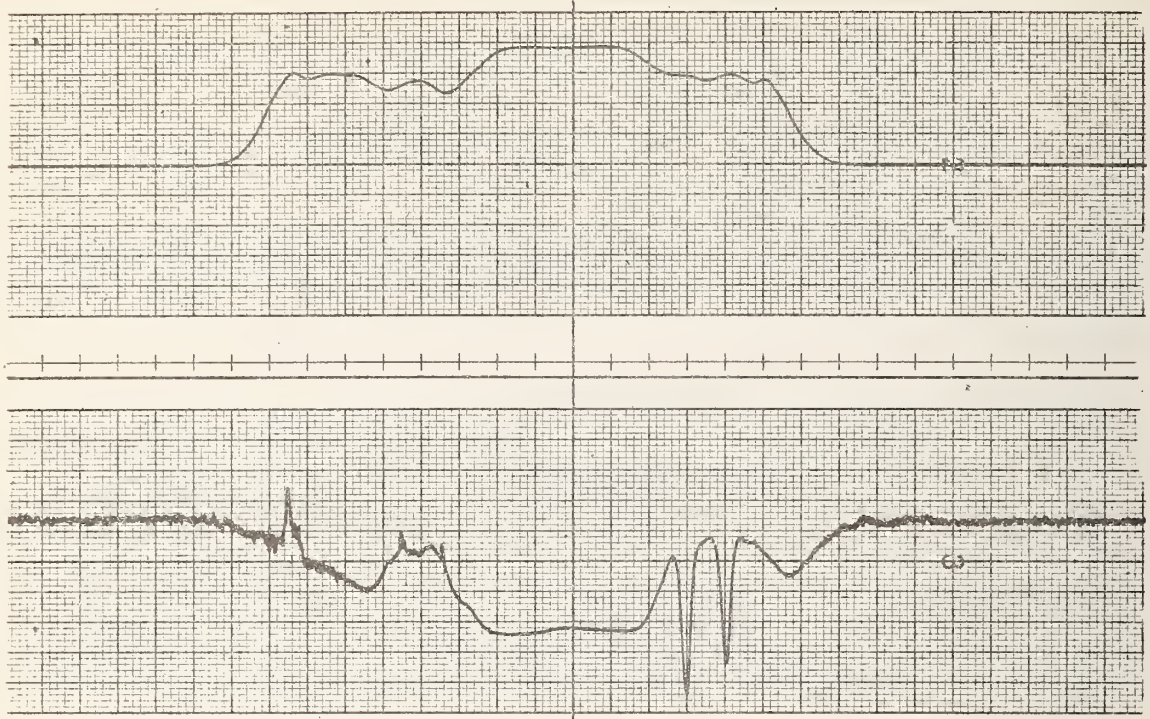

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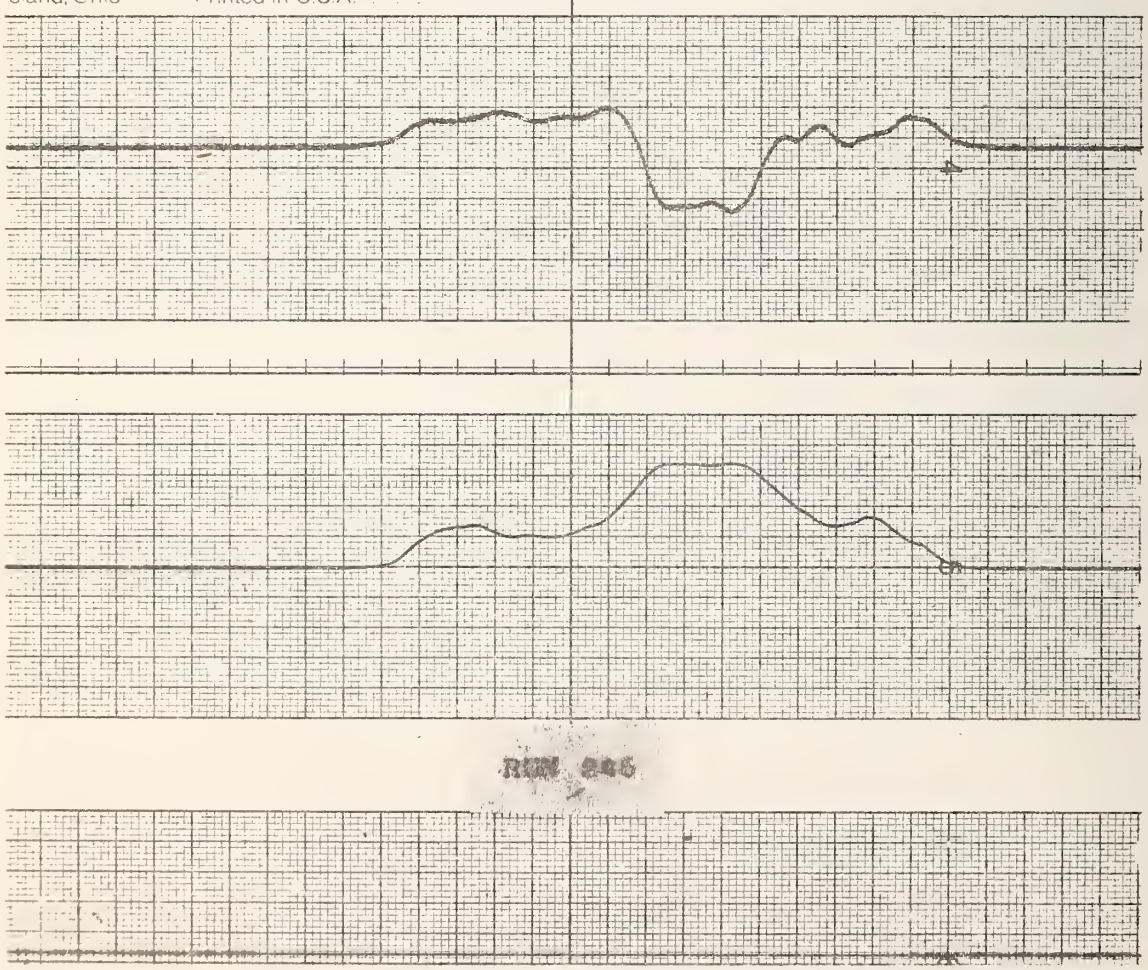

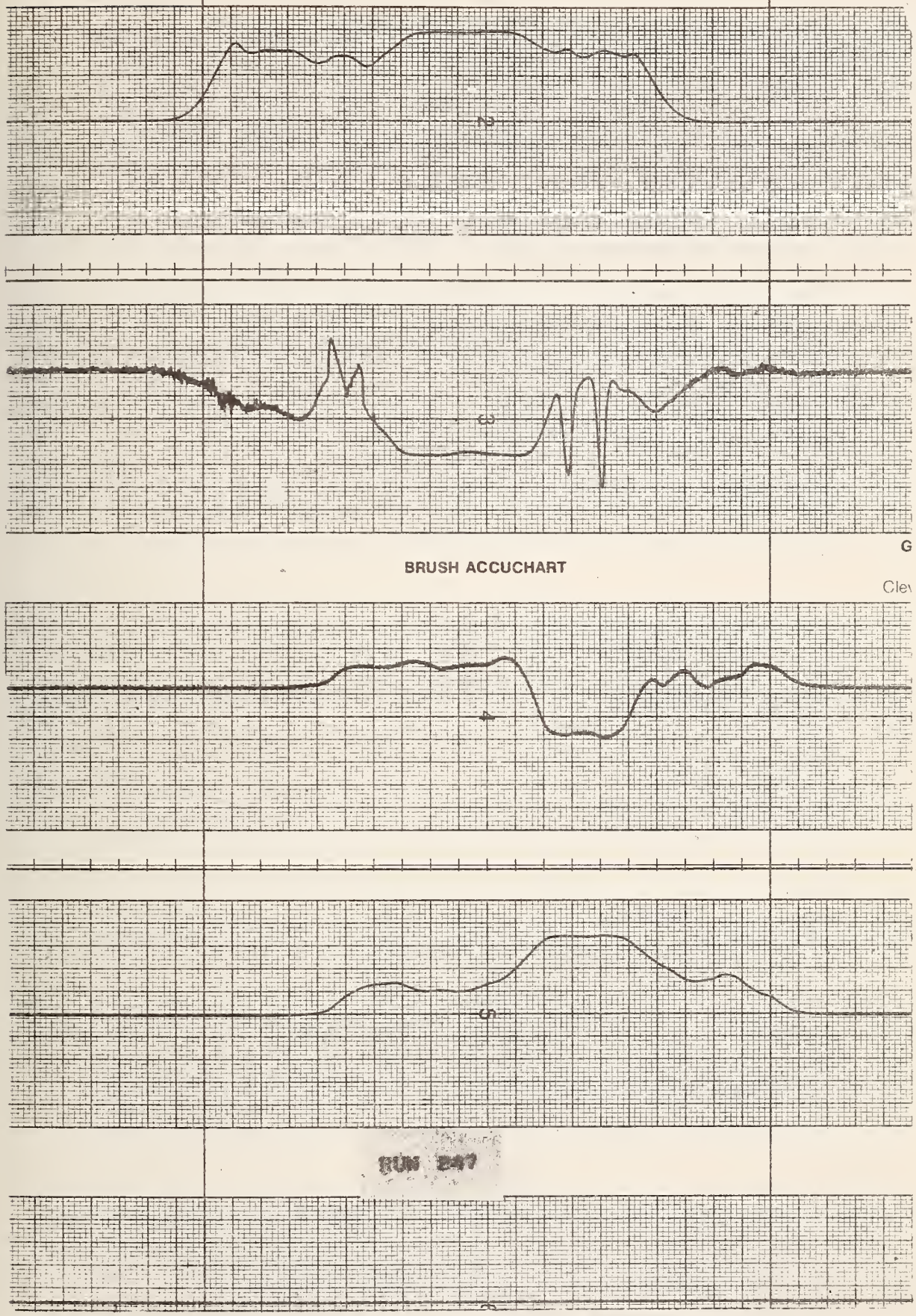
BRUSH ACCUCHART
RUN 247

Run 248

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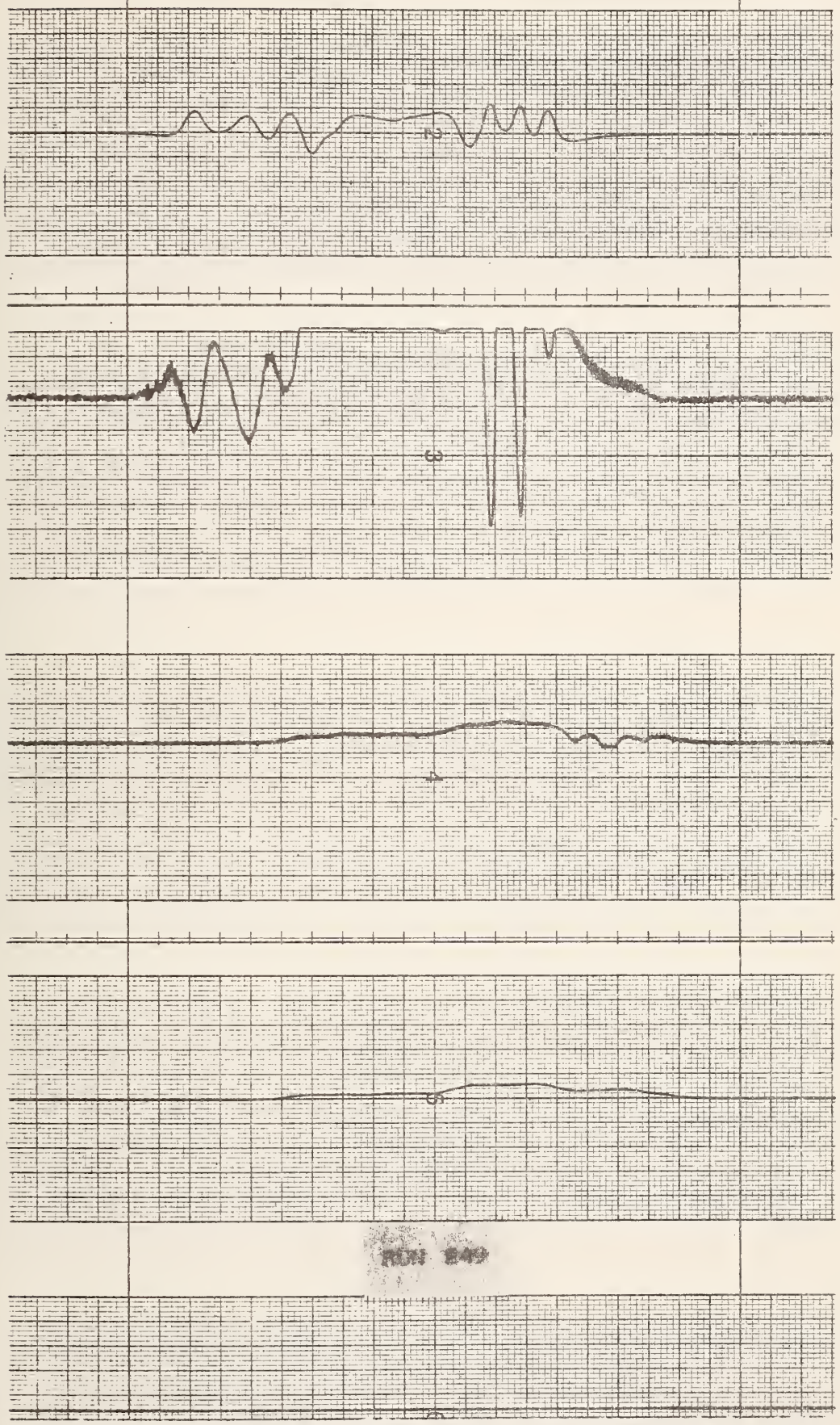
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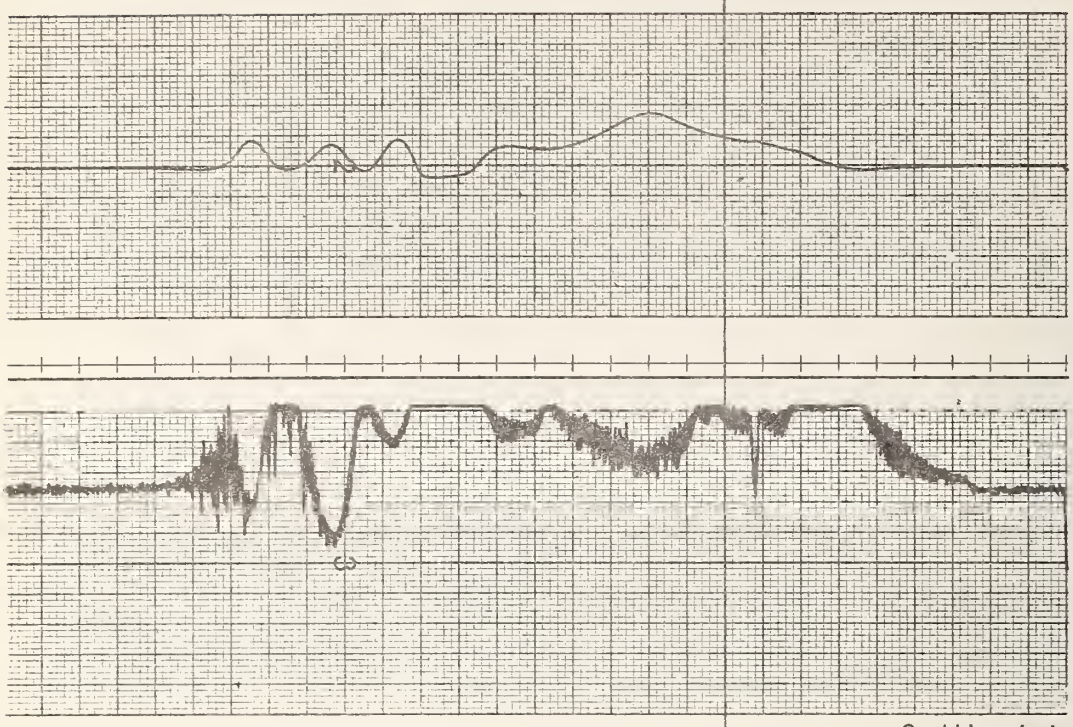

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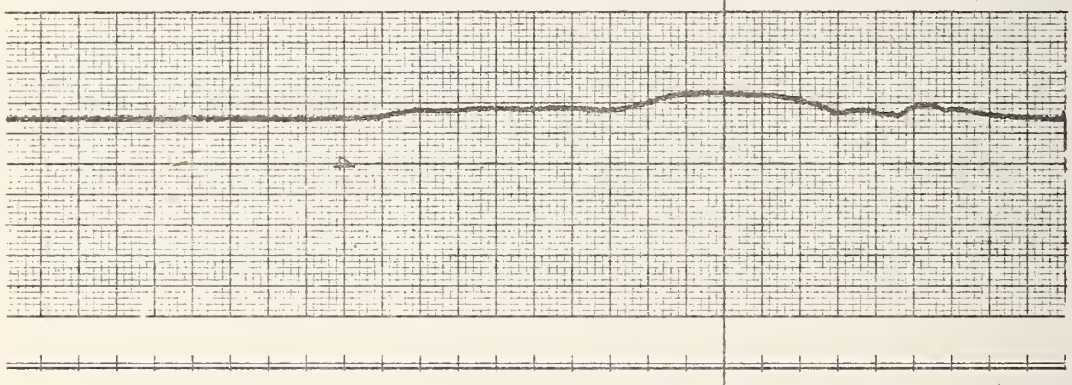
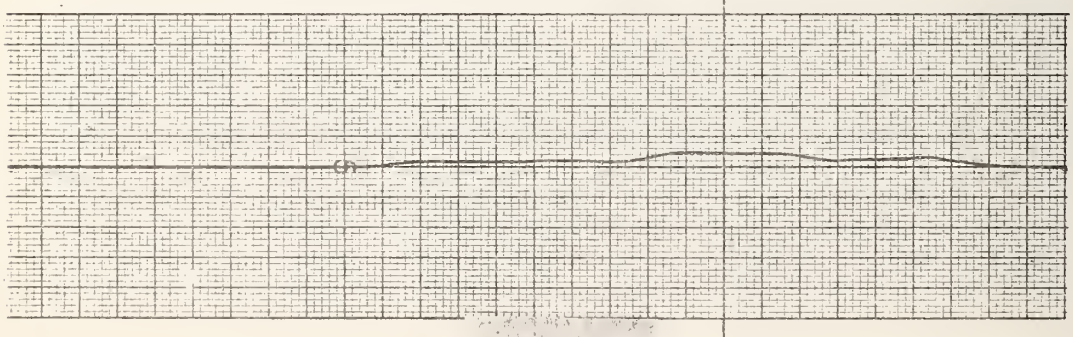
Cleveland, Ohio





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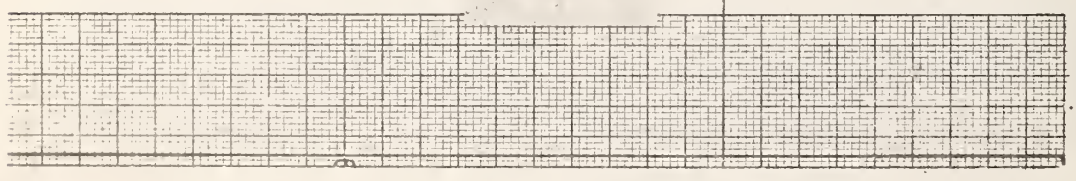

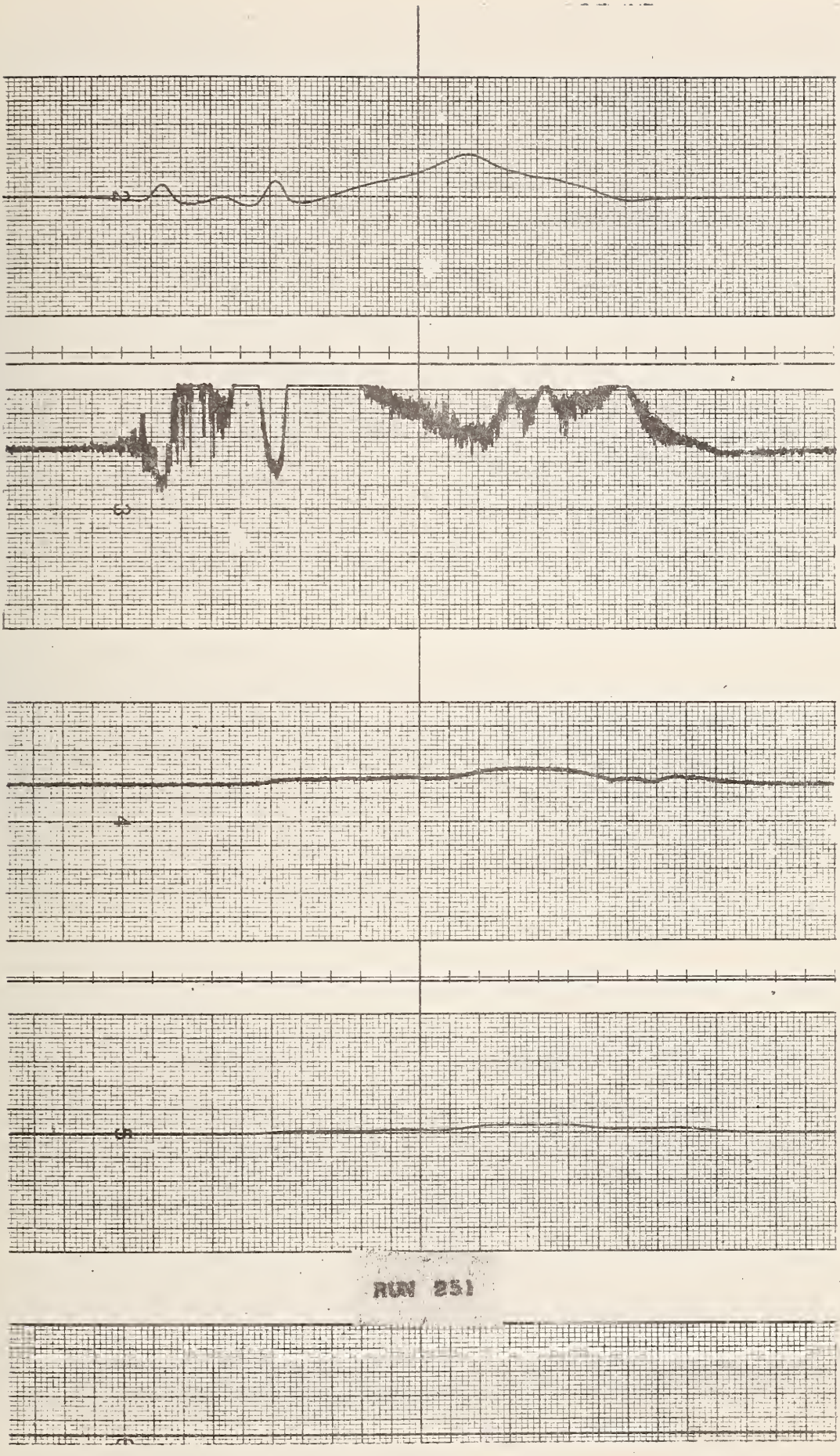
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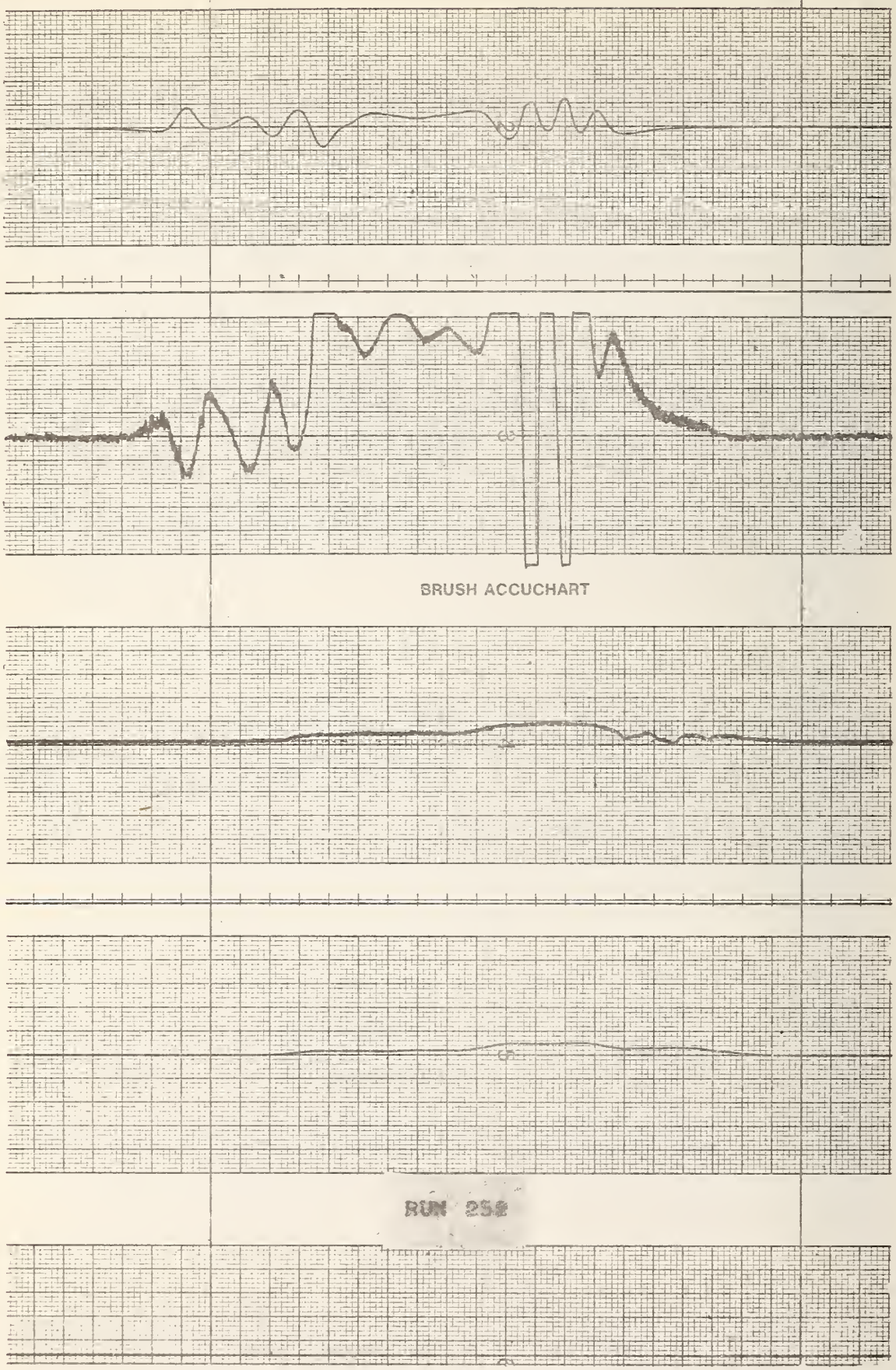
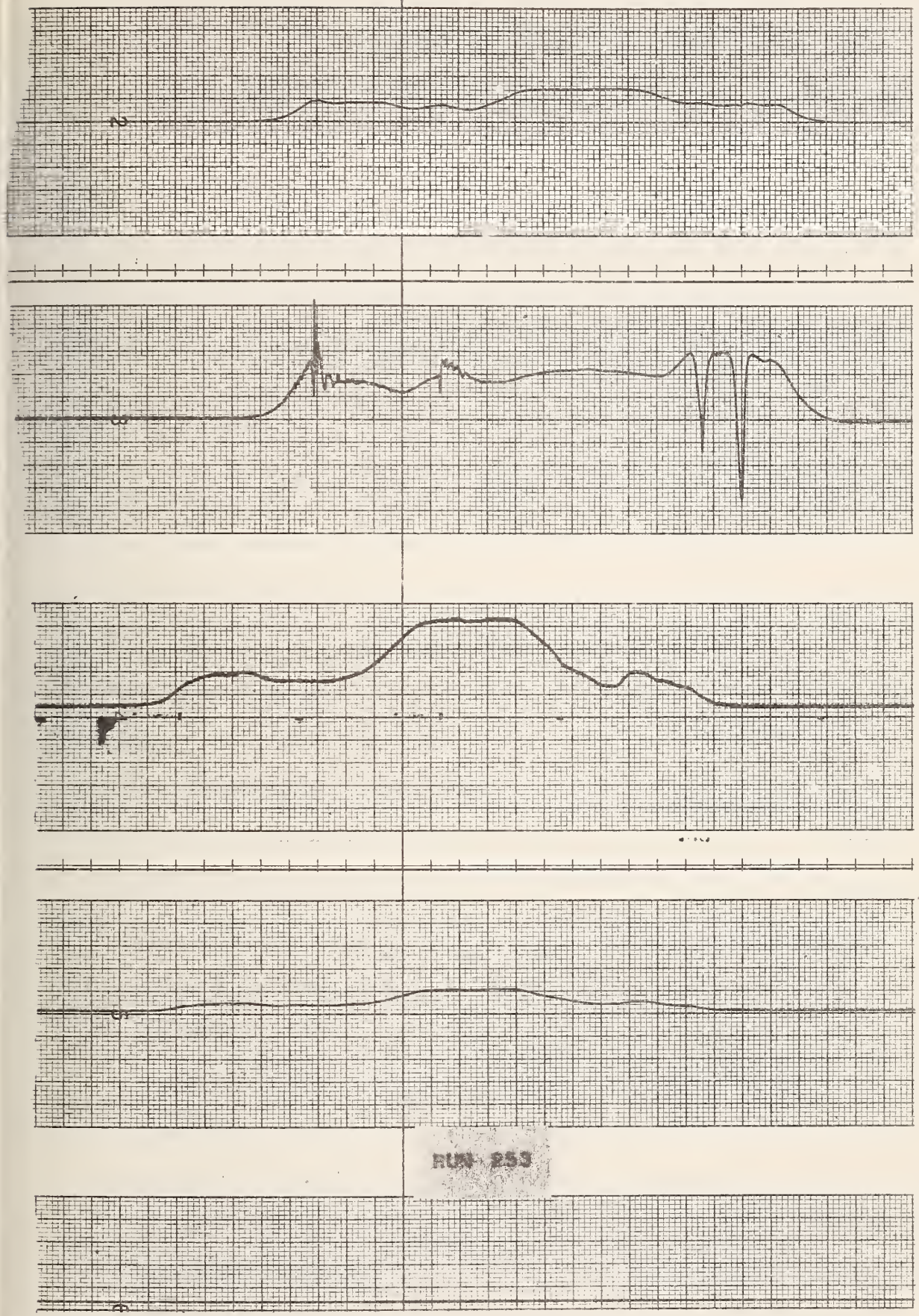

BRUSH ACCUCHART
RUN 258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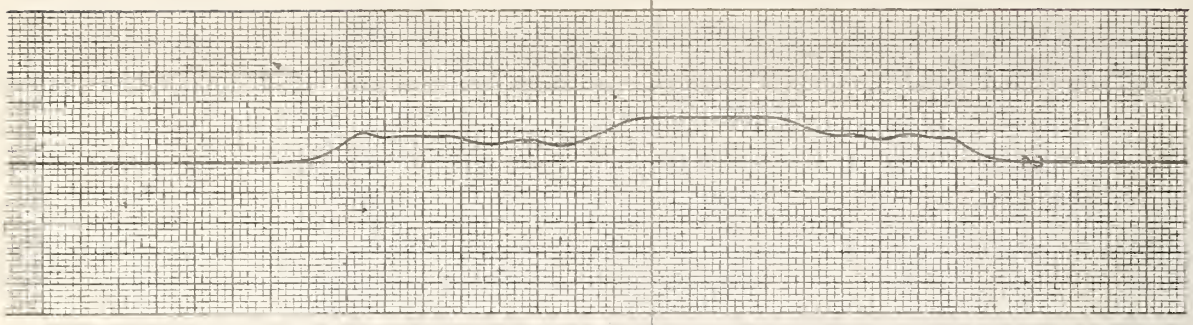

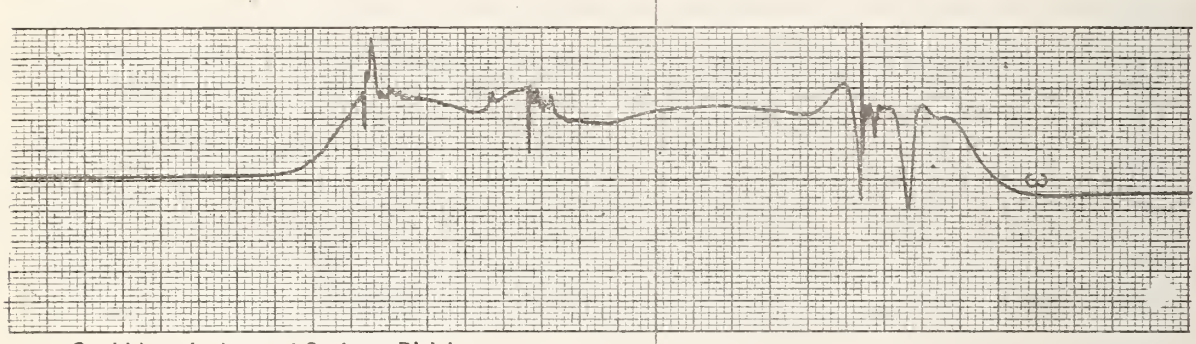

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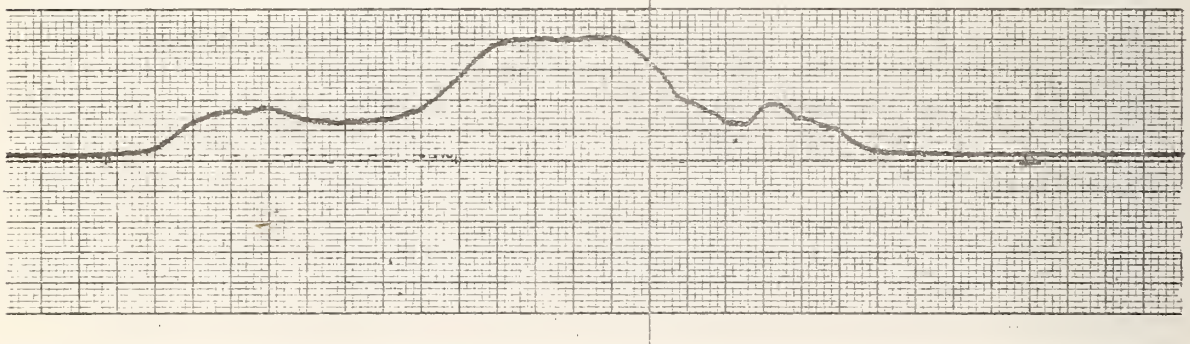

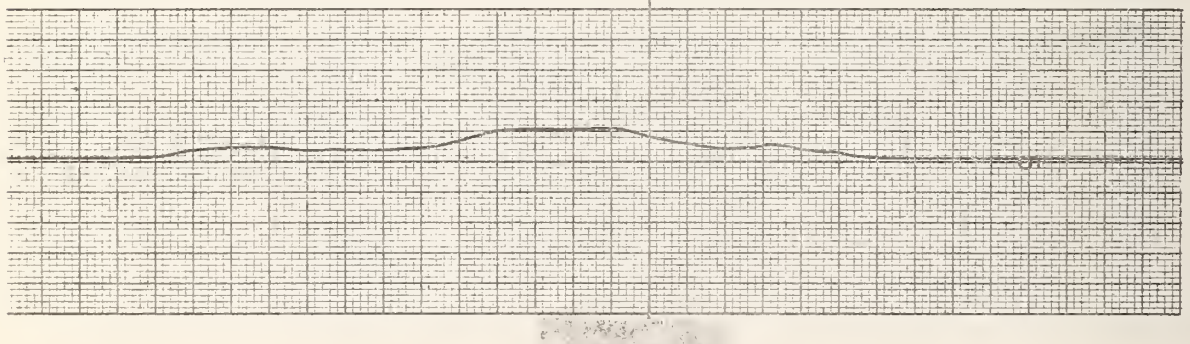

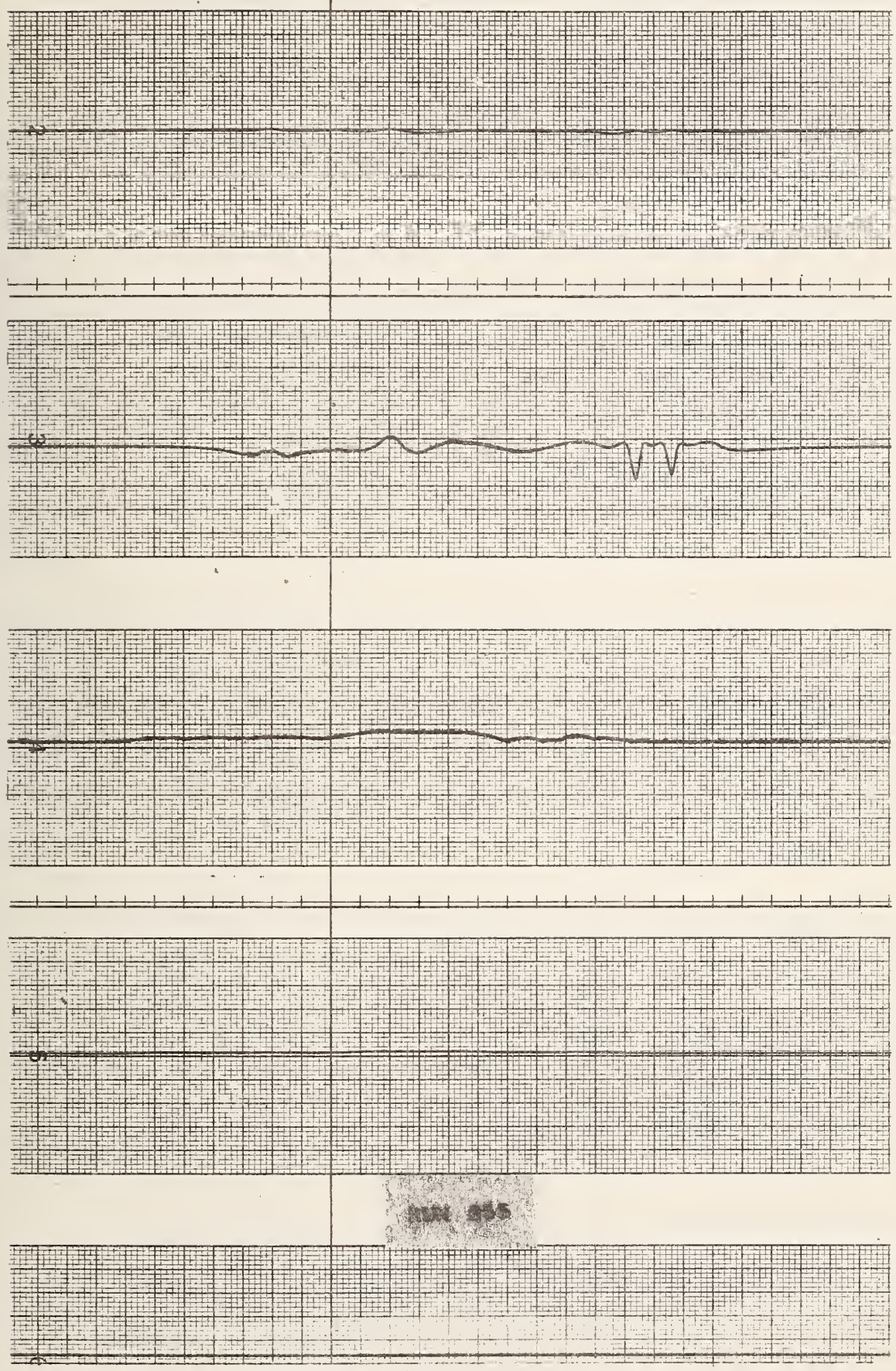

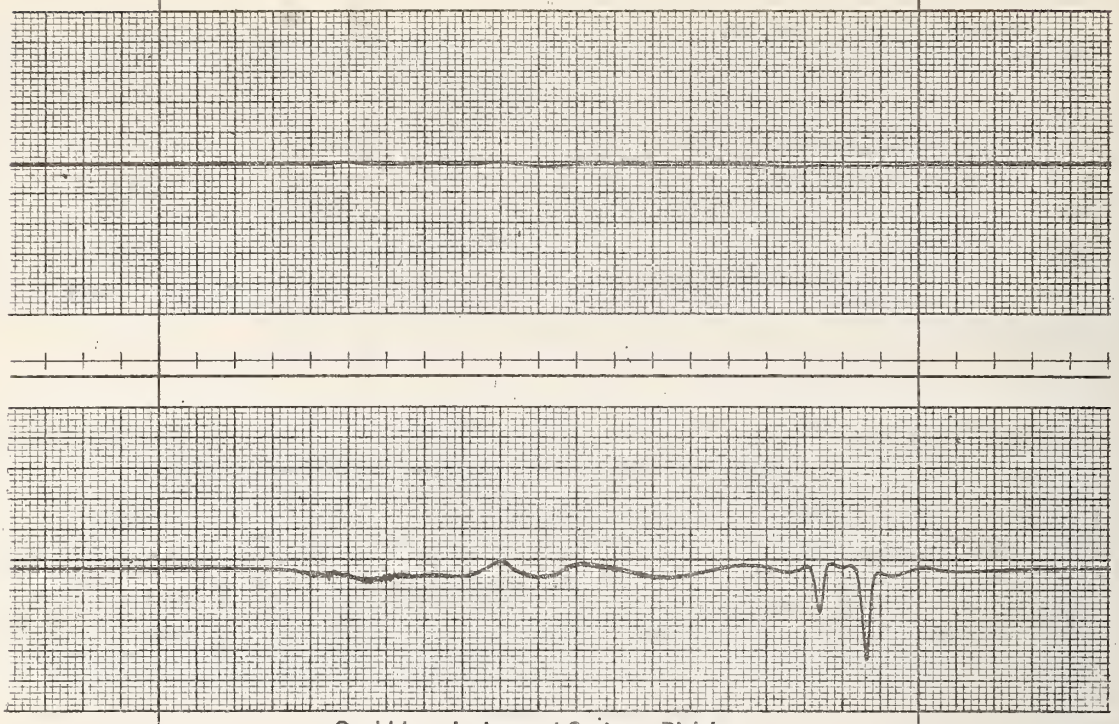

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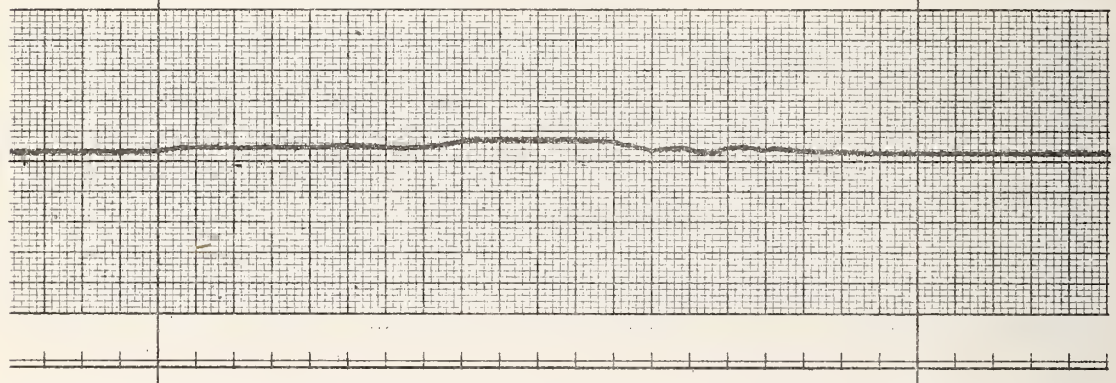

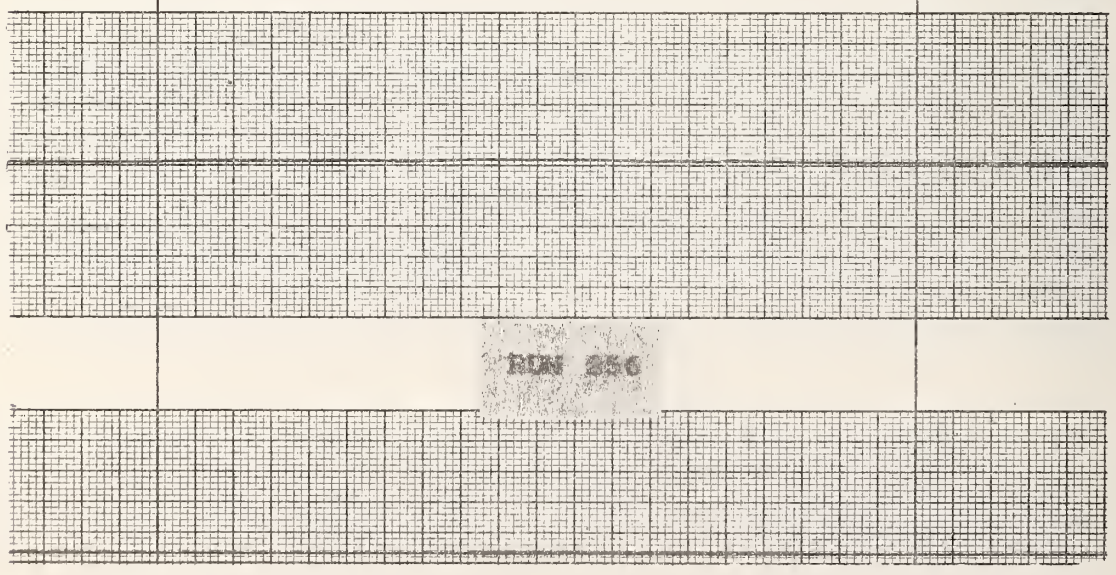

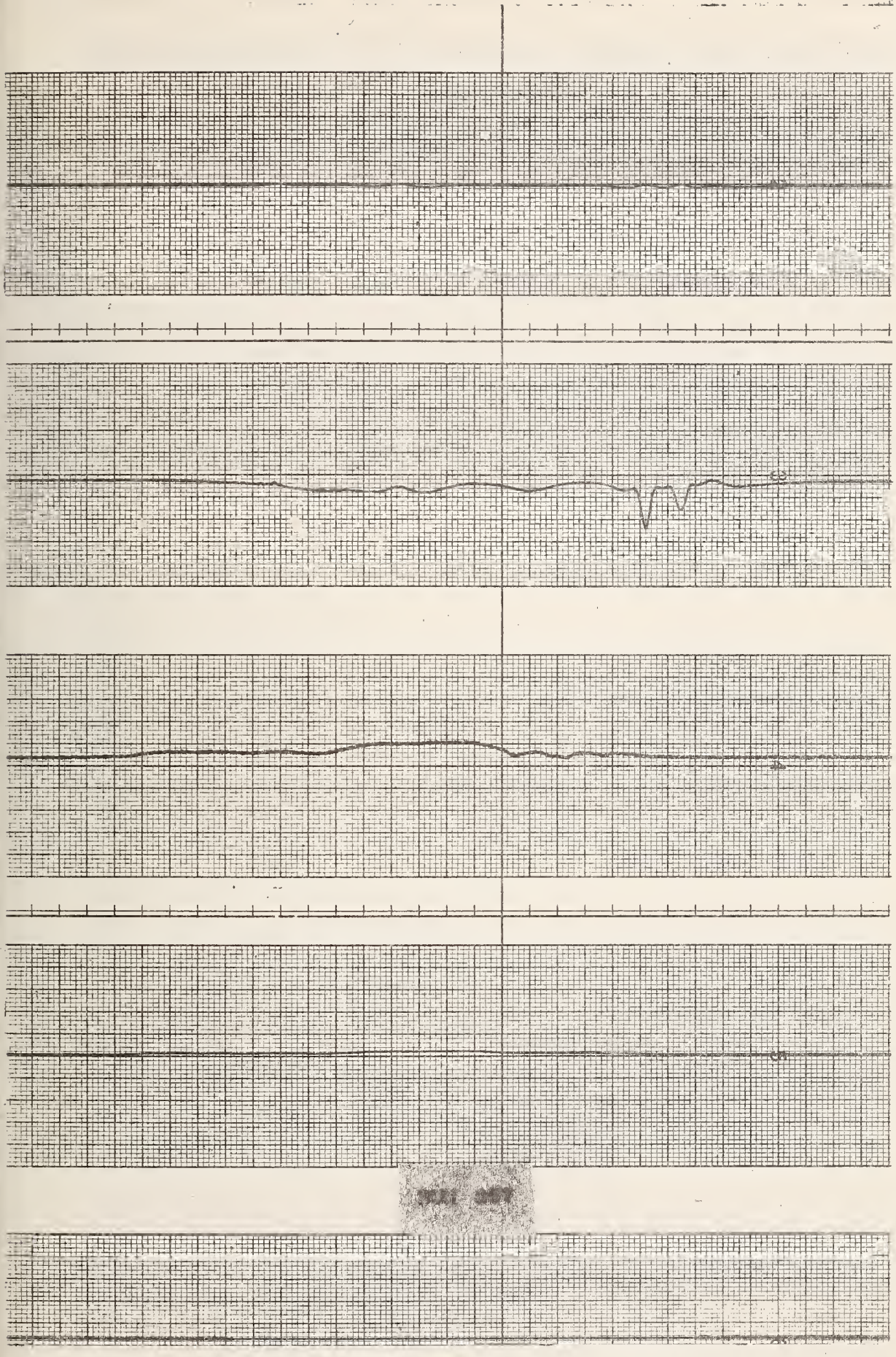

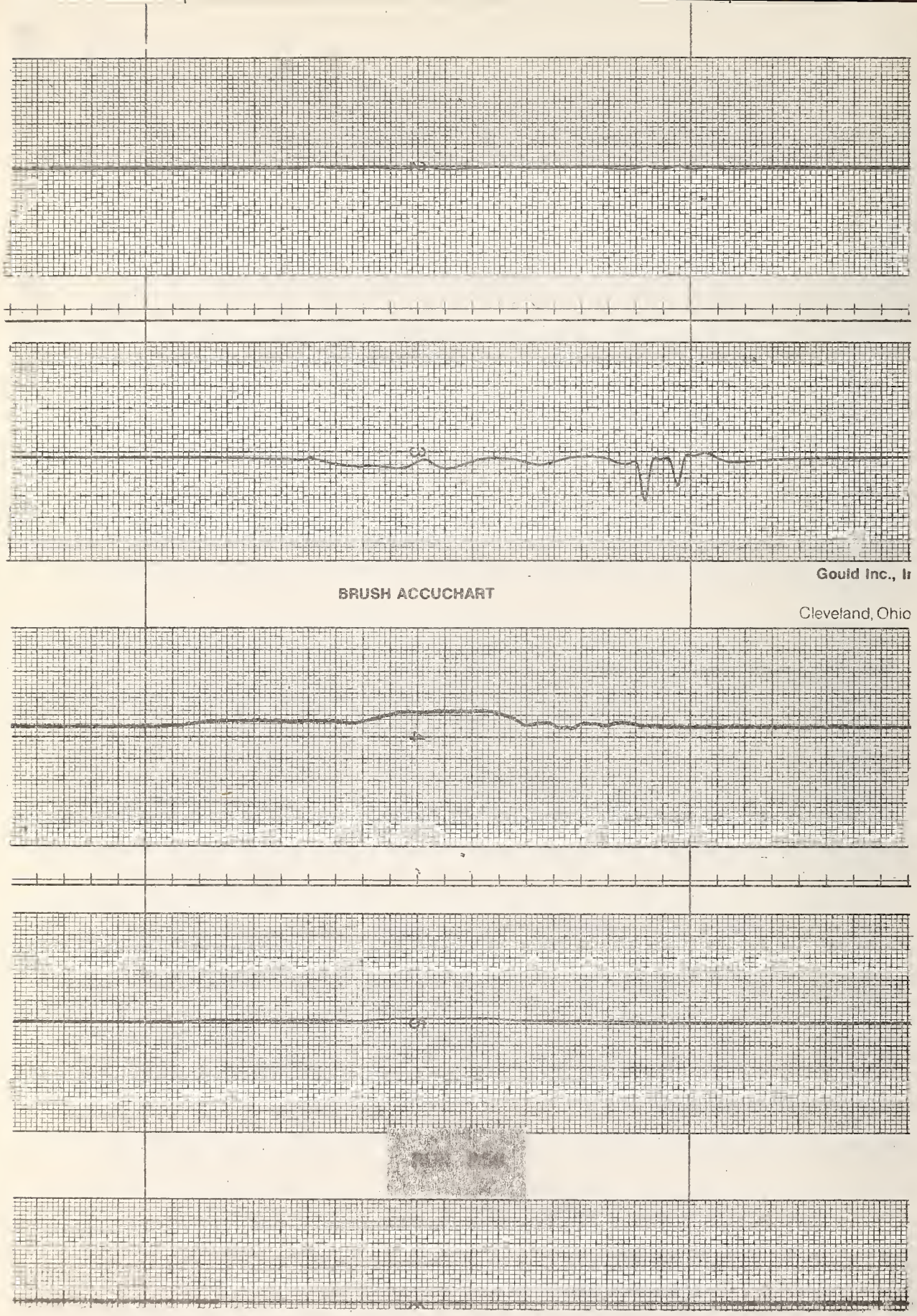
Gould Inc., In
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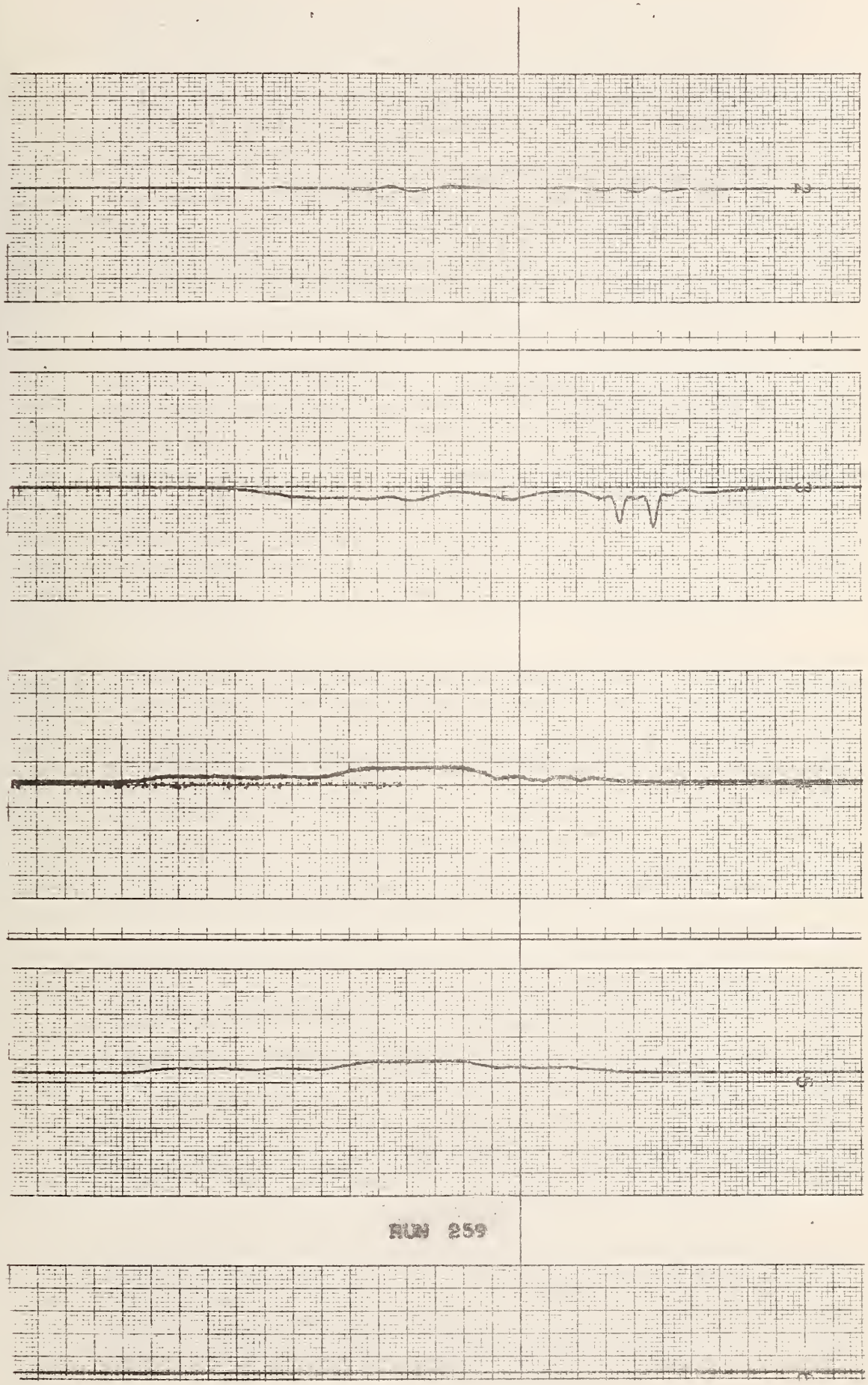
Cleveland, Ohio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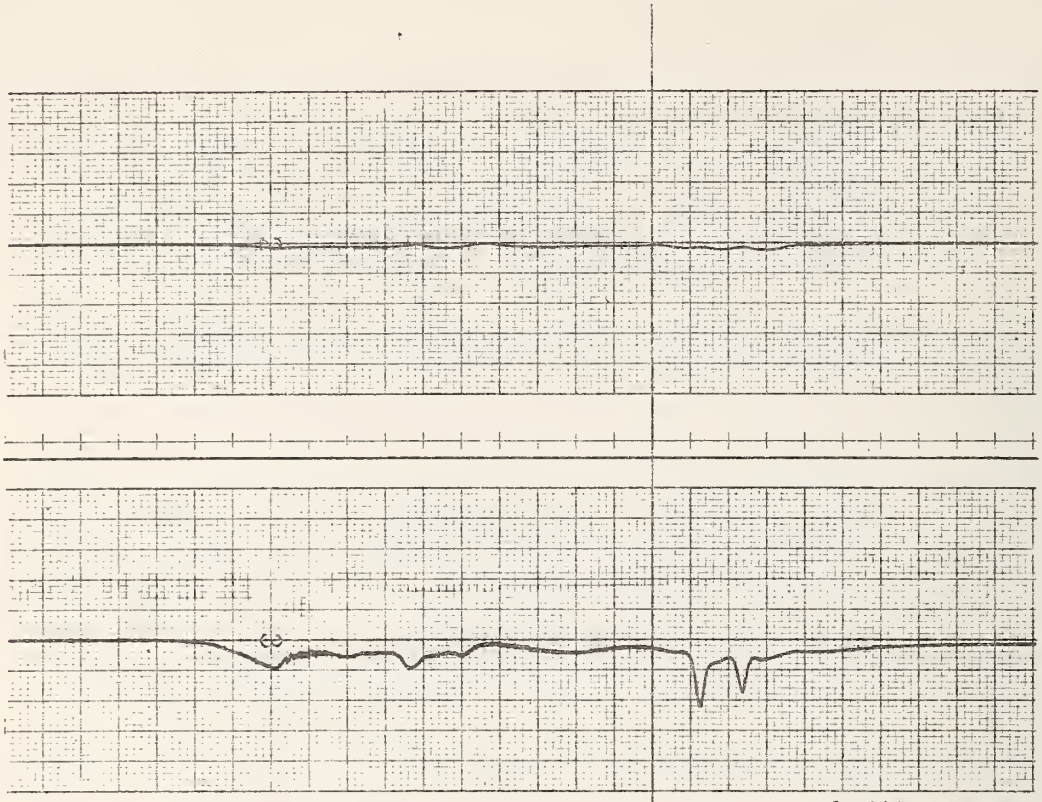
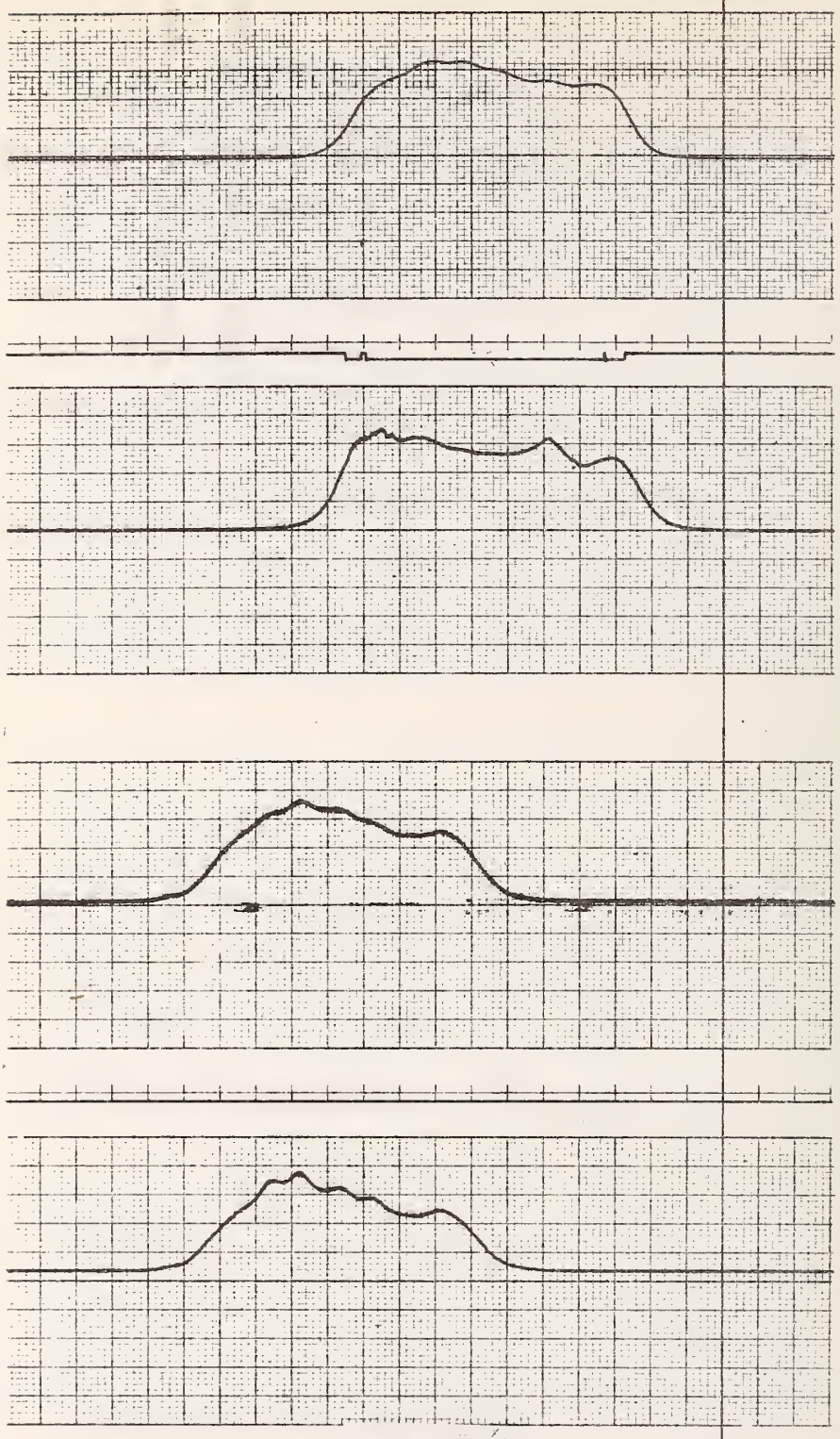

Gould Inc., Instrume
BRUSH ACCUCHART
Cleveland, Ohio
RUN 260

RUN 261



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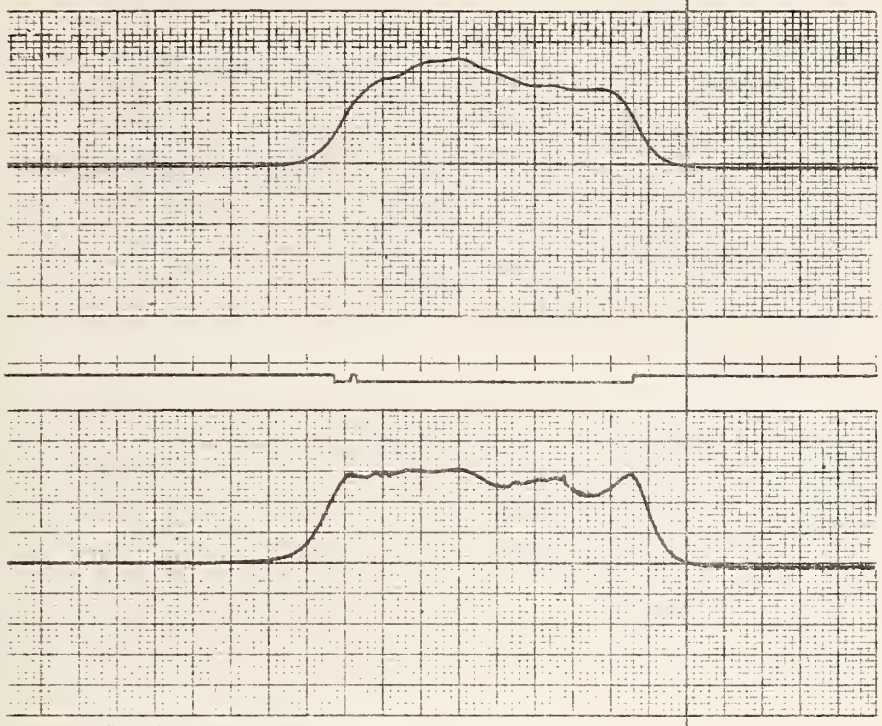

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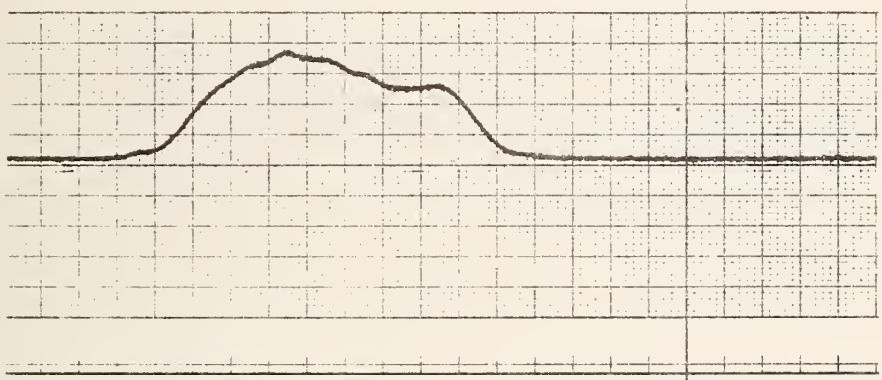

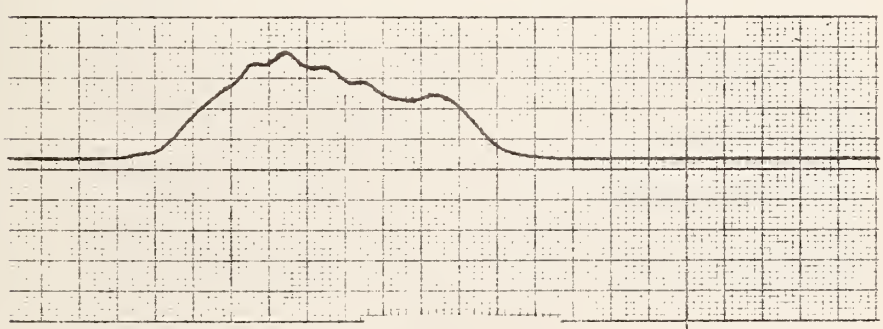

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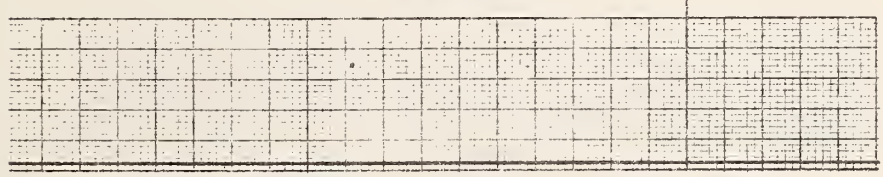
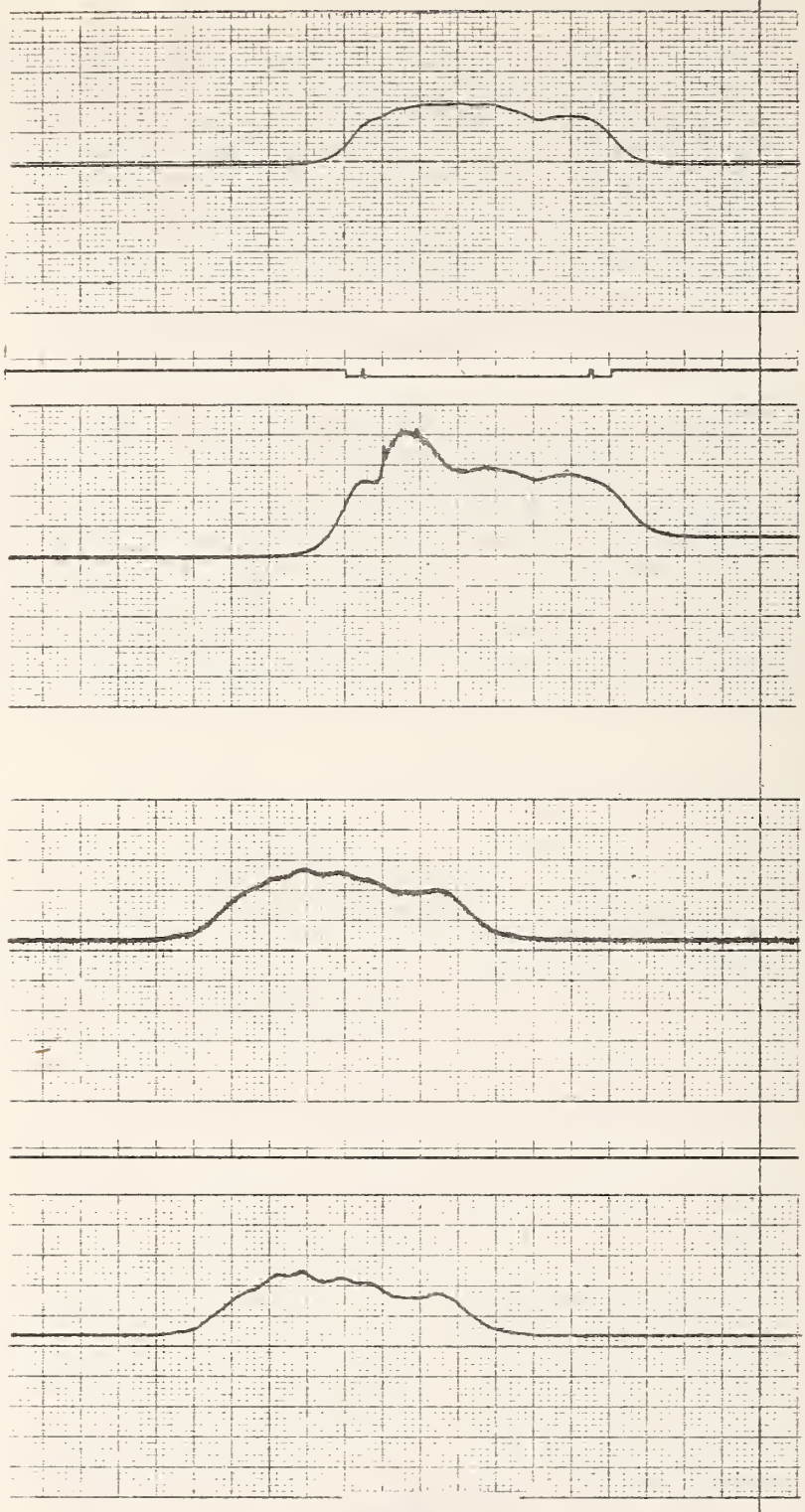
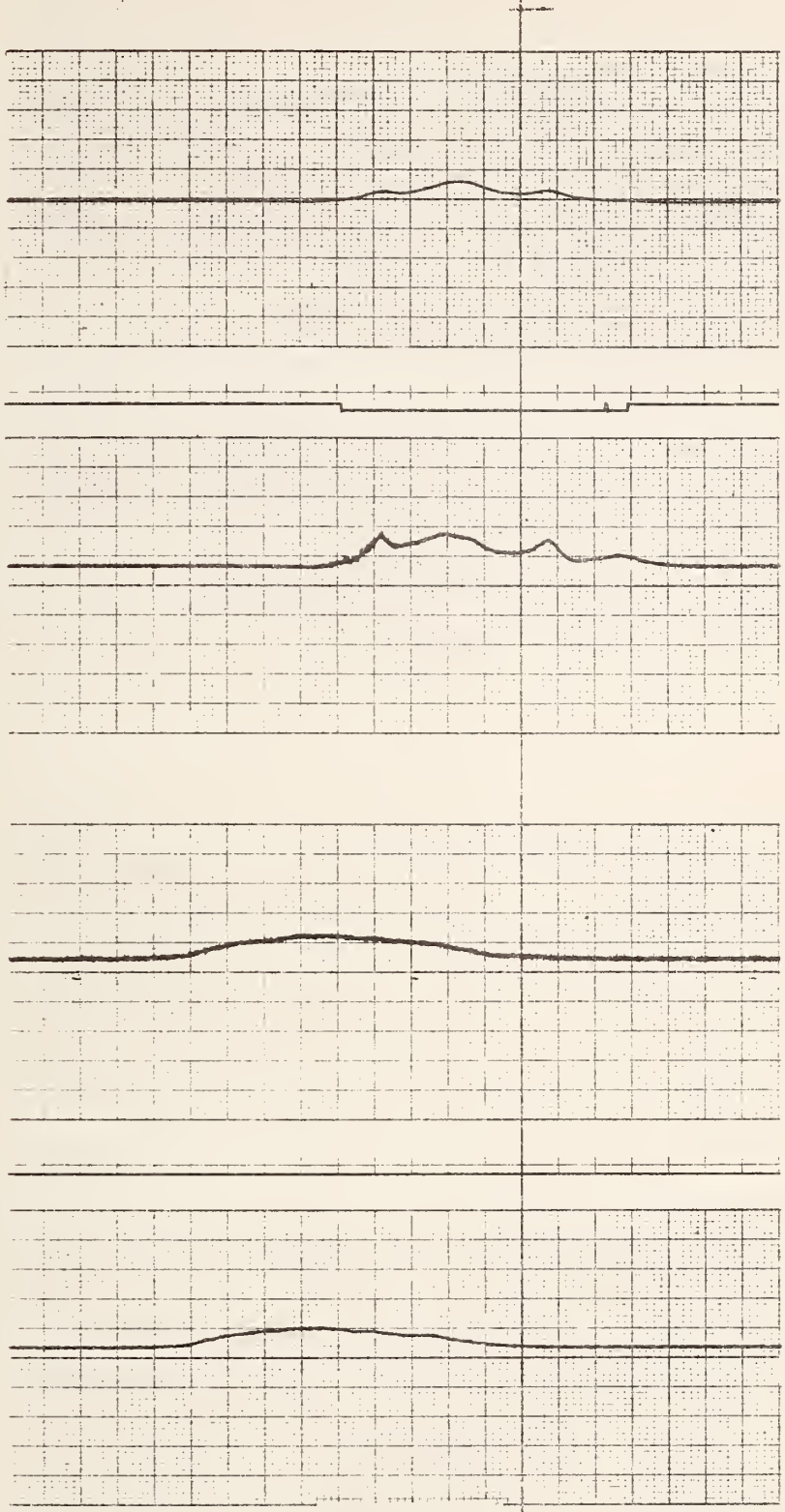




RUN 264



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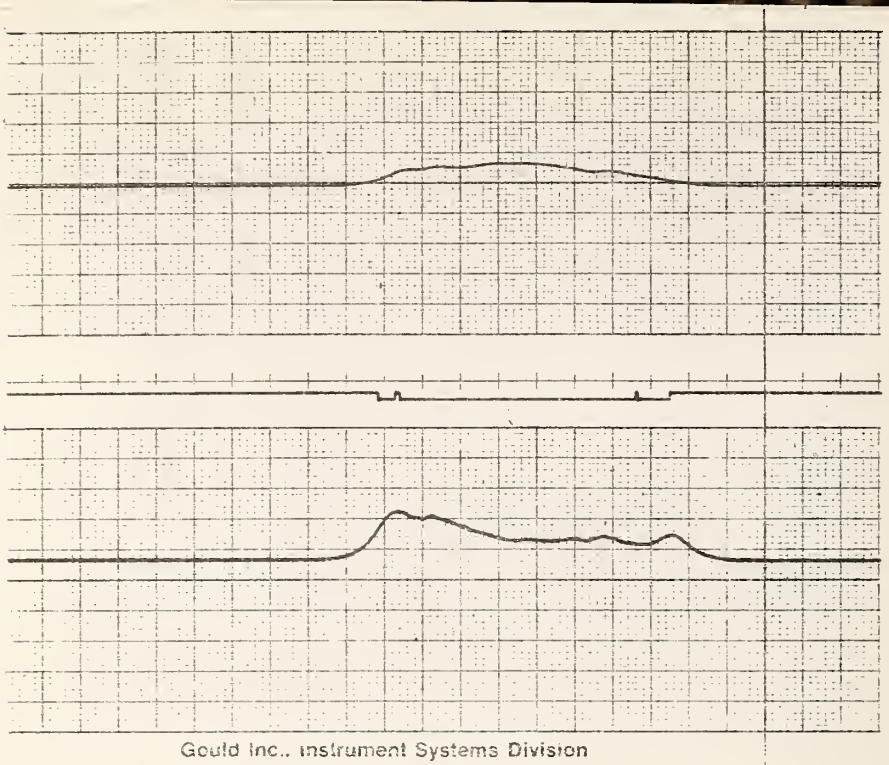

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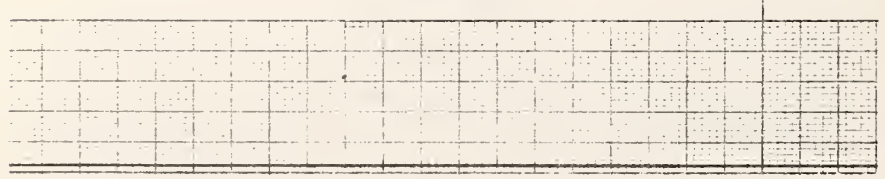
RUN 266



Run 267

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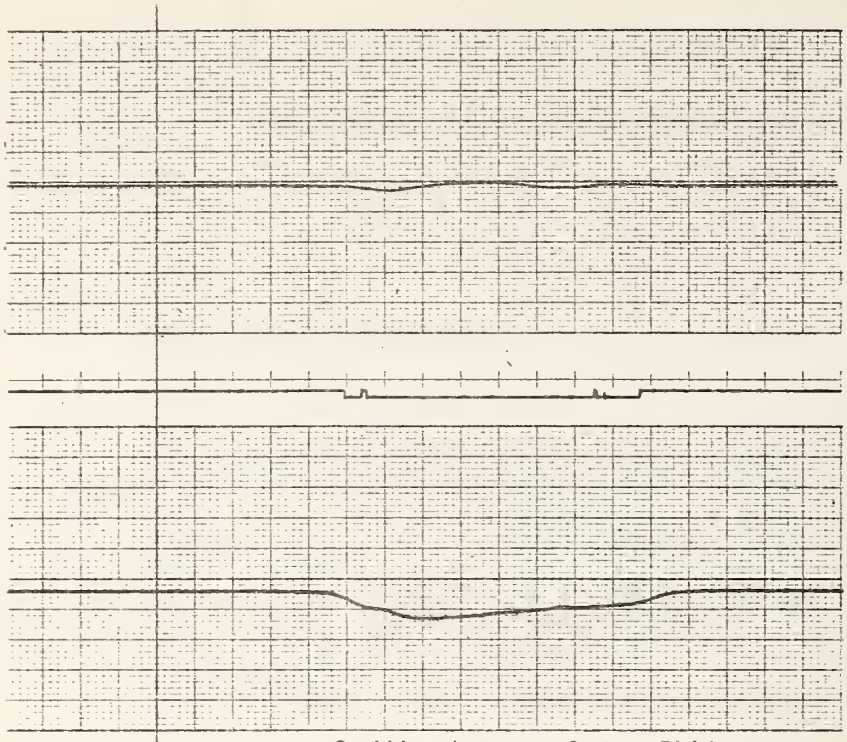
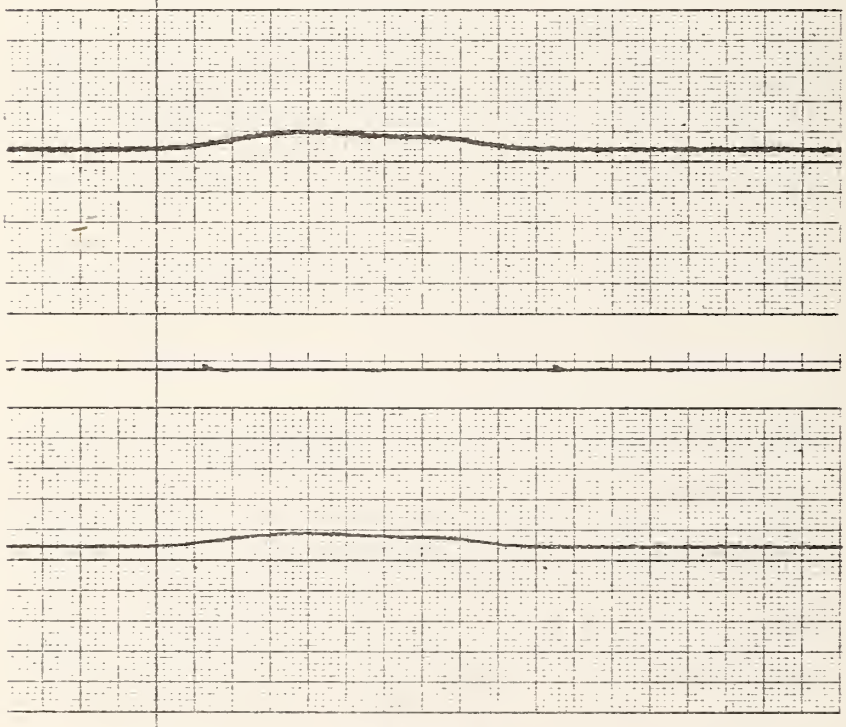


Gould Inc., Instrument Systems Division

Cleveland, Ohio Printed in U.S.A.



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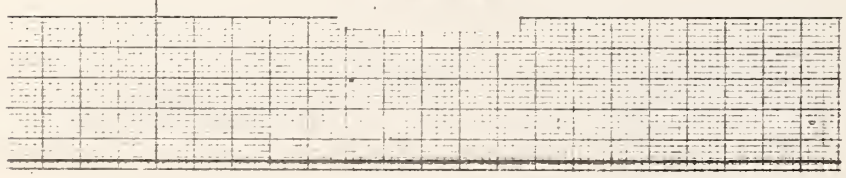
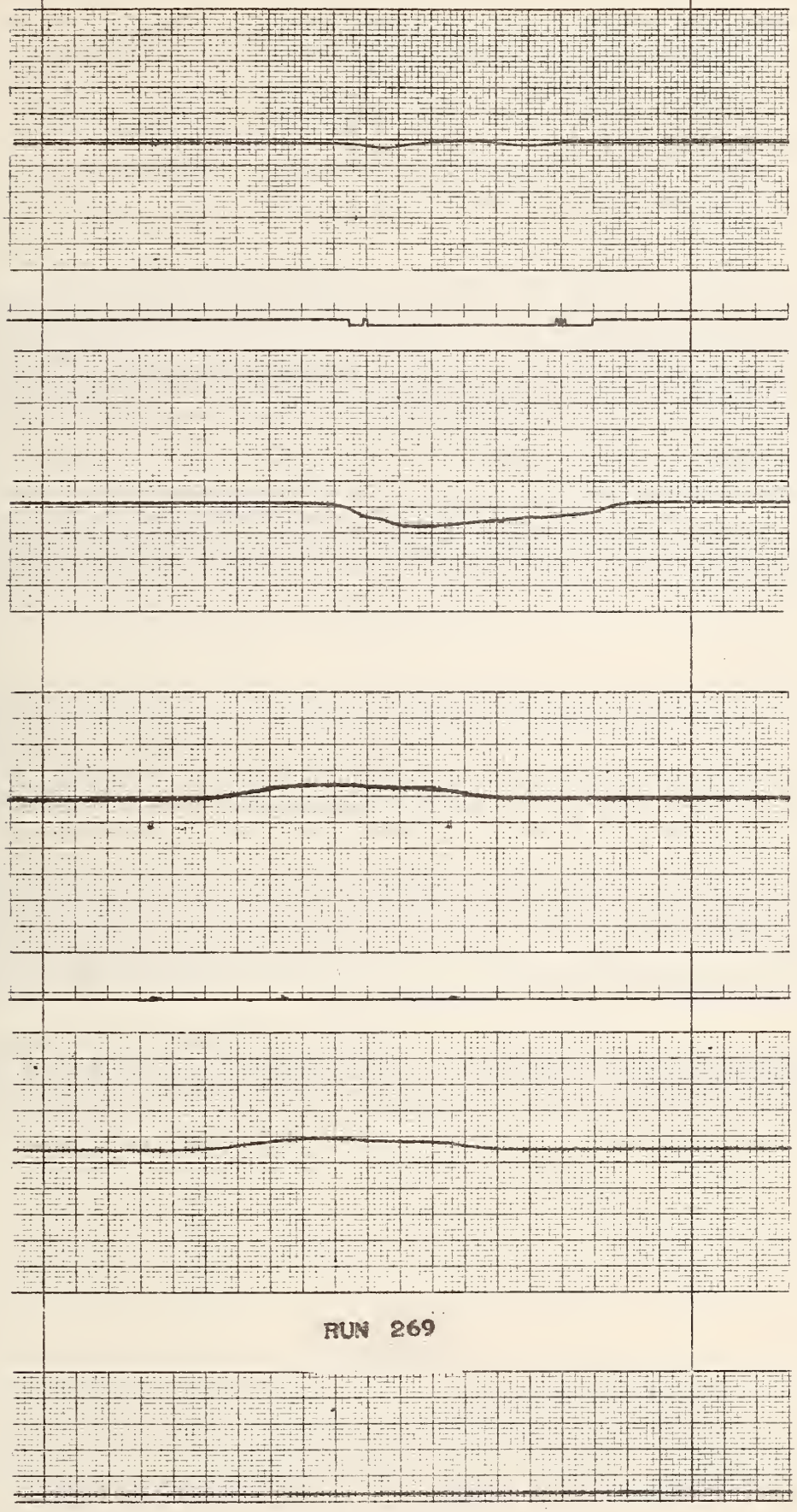
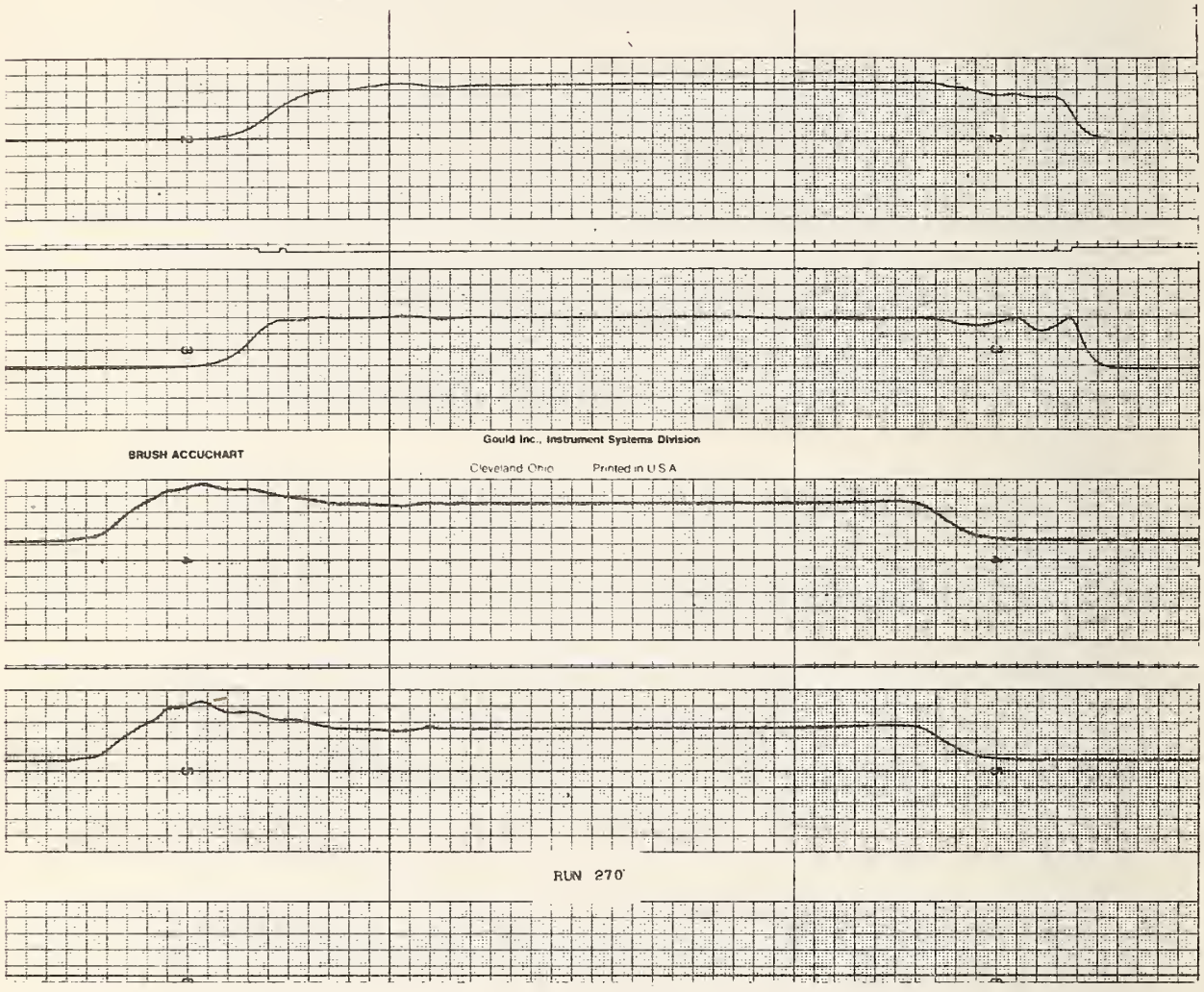
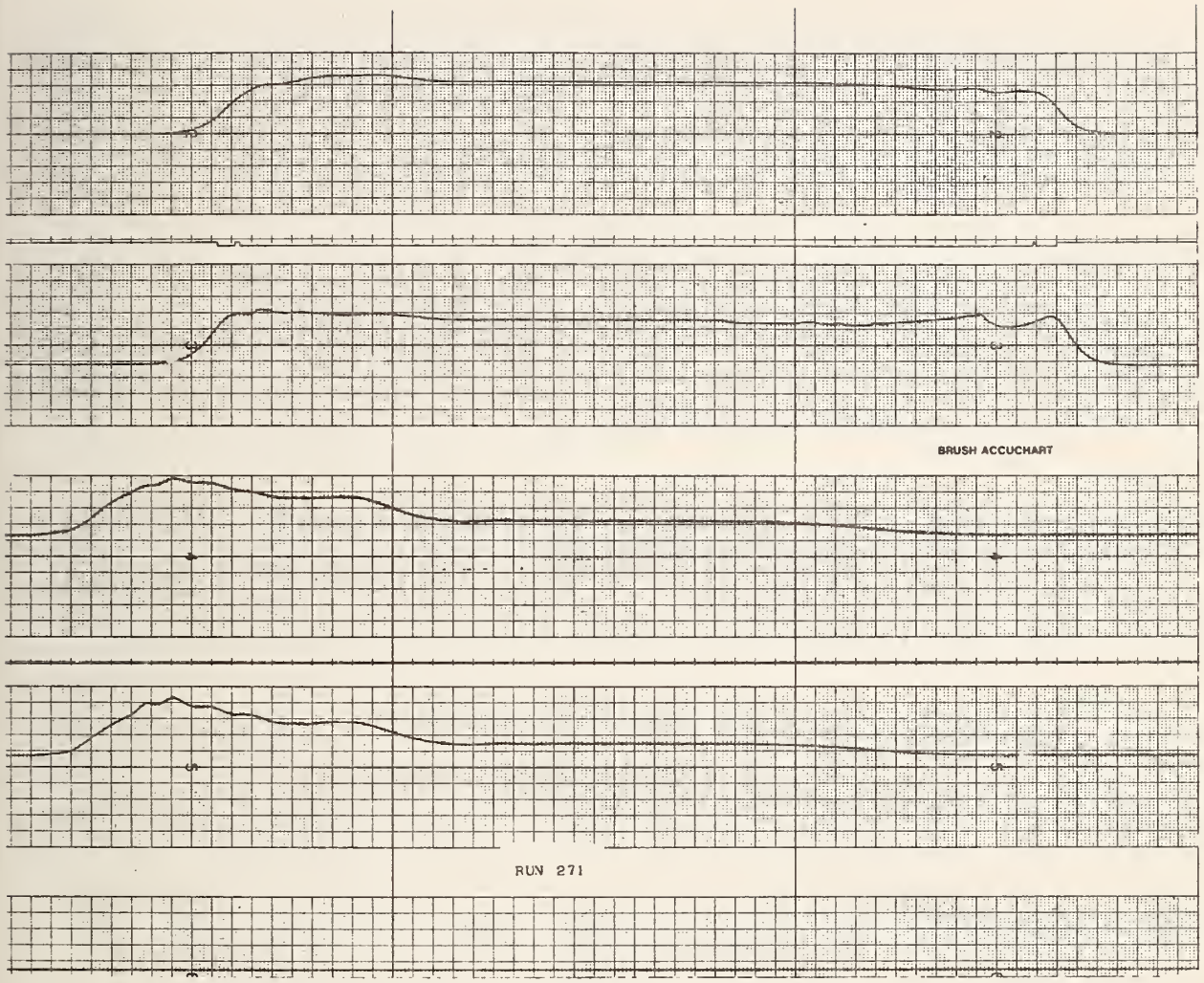




RUN 269


BRUSH ACCUCHART
Gould Inc., Instrument Systems Division
Cleveland Ohio Printed in U.S.A.
RUN 270'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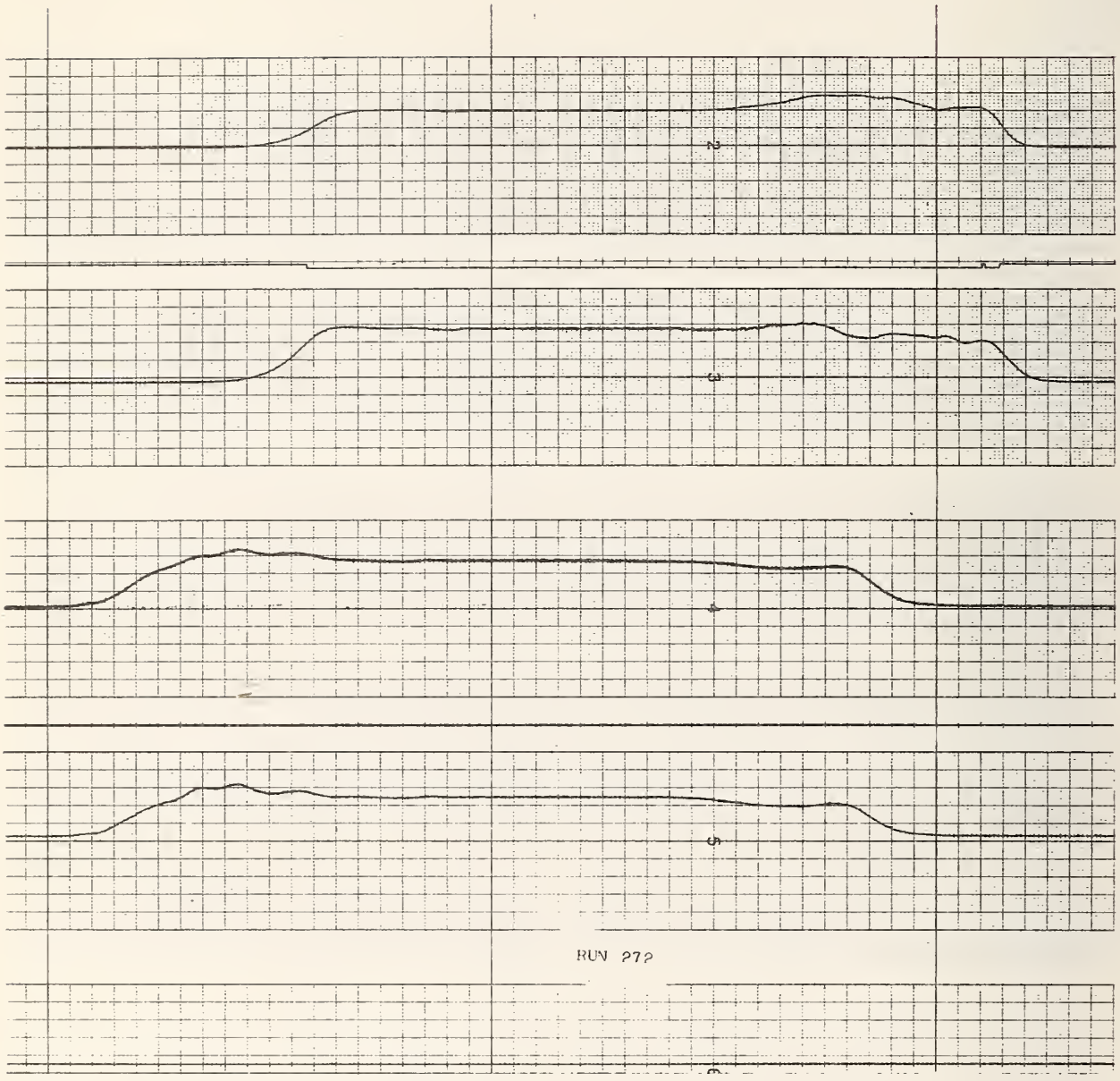
RUN 271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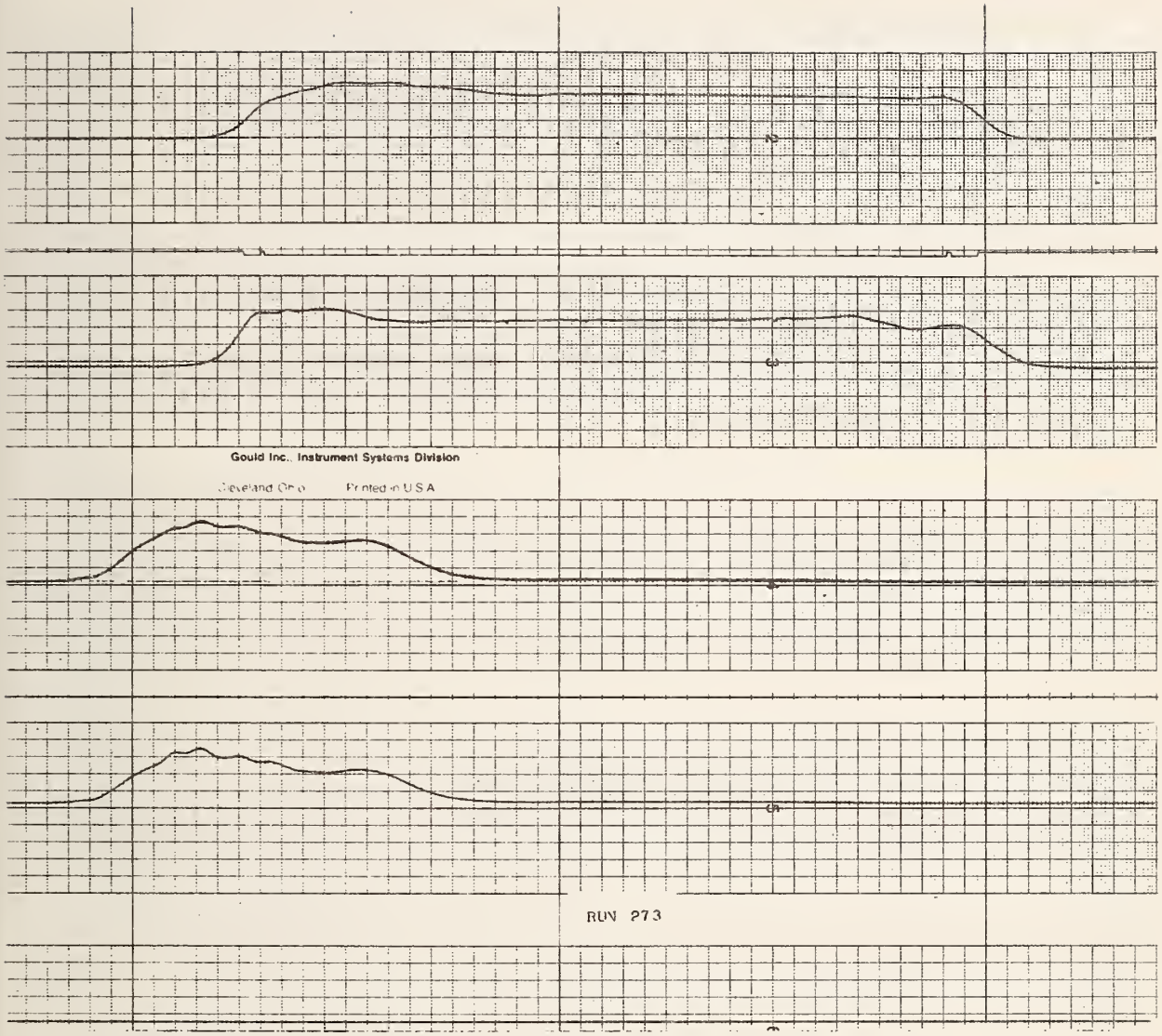
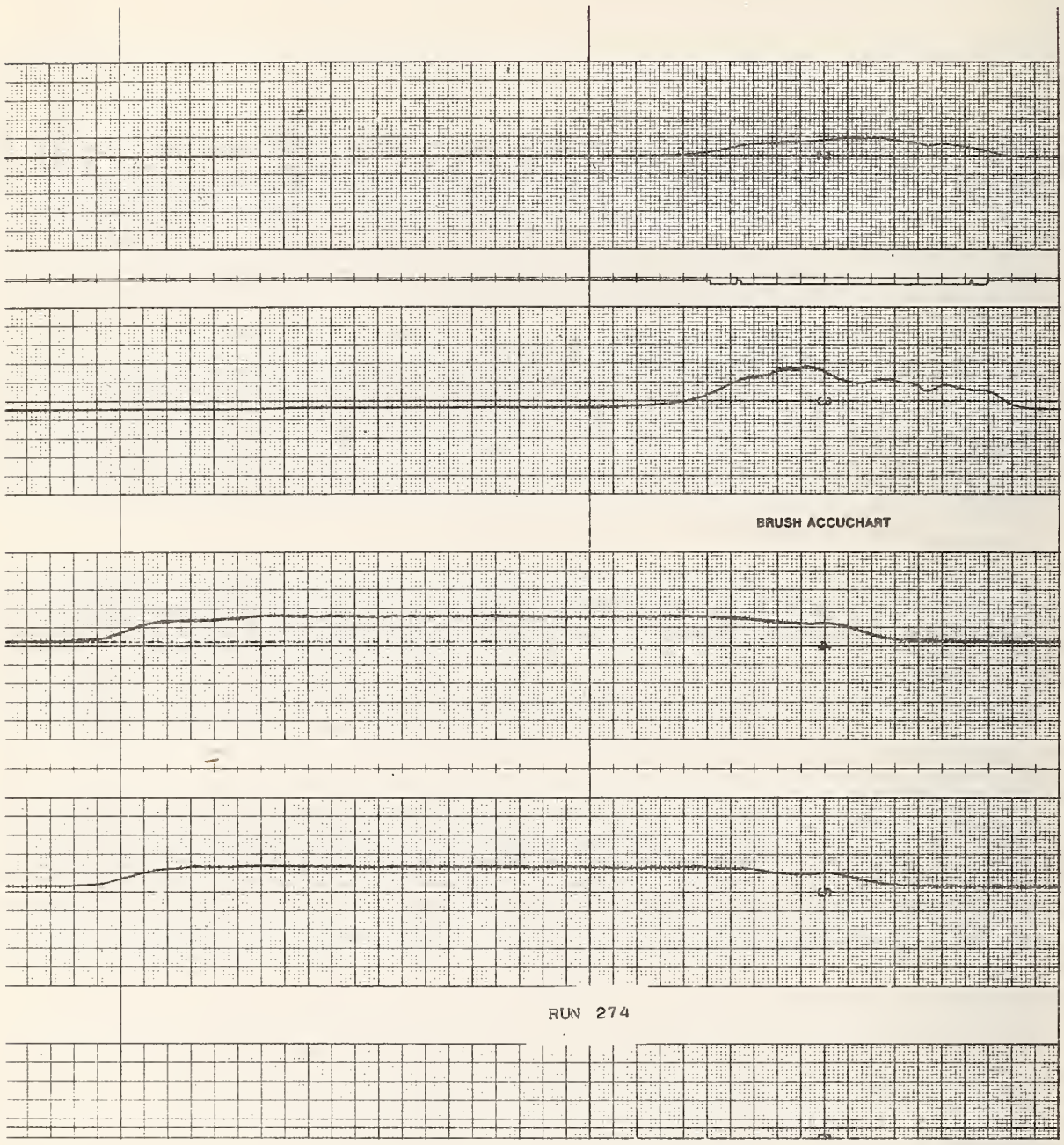

Gould Inc. Instrument Systems Division
Cleveland Ohio Printed in U.S.A.
RUN 273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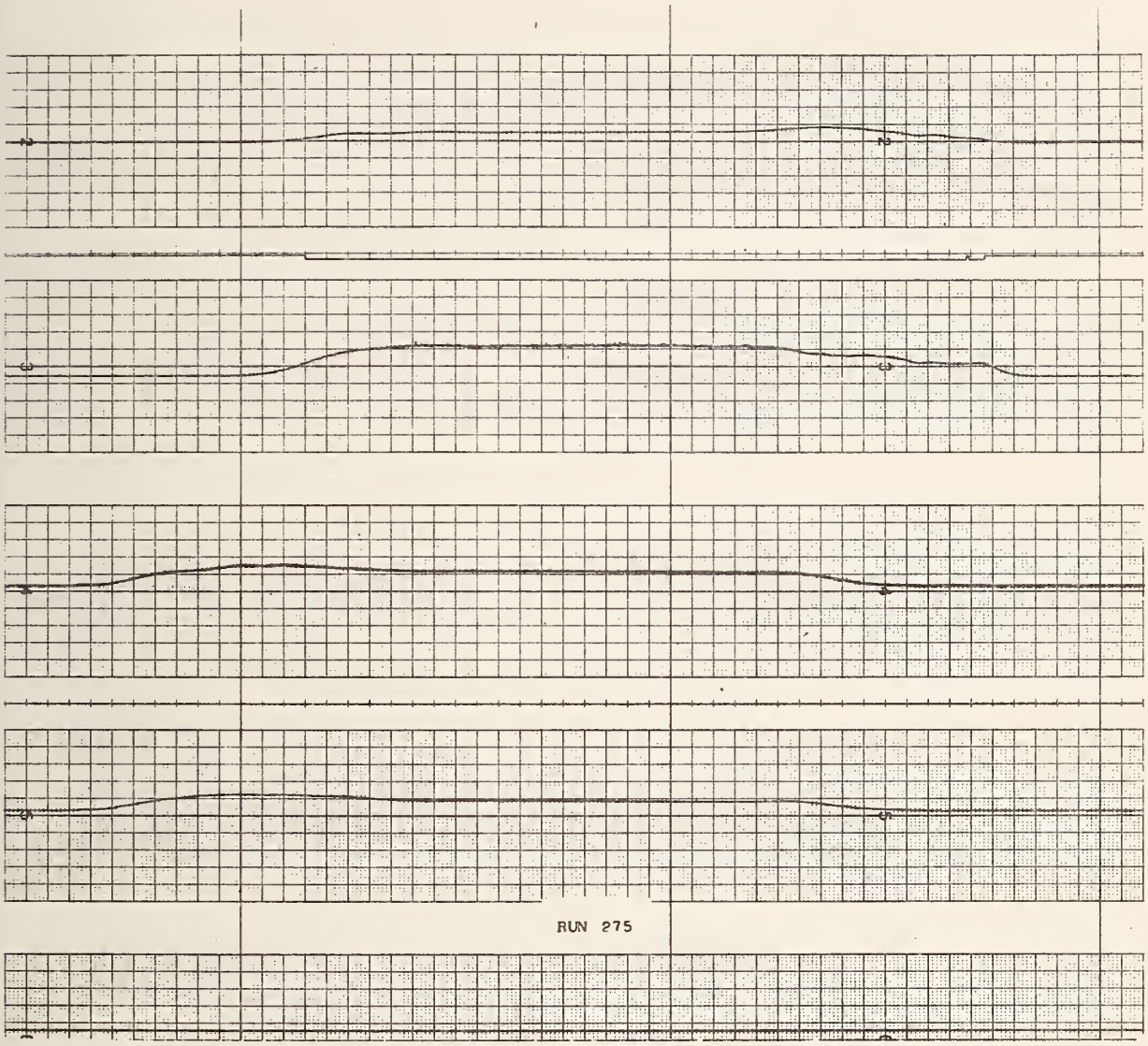
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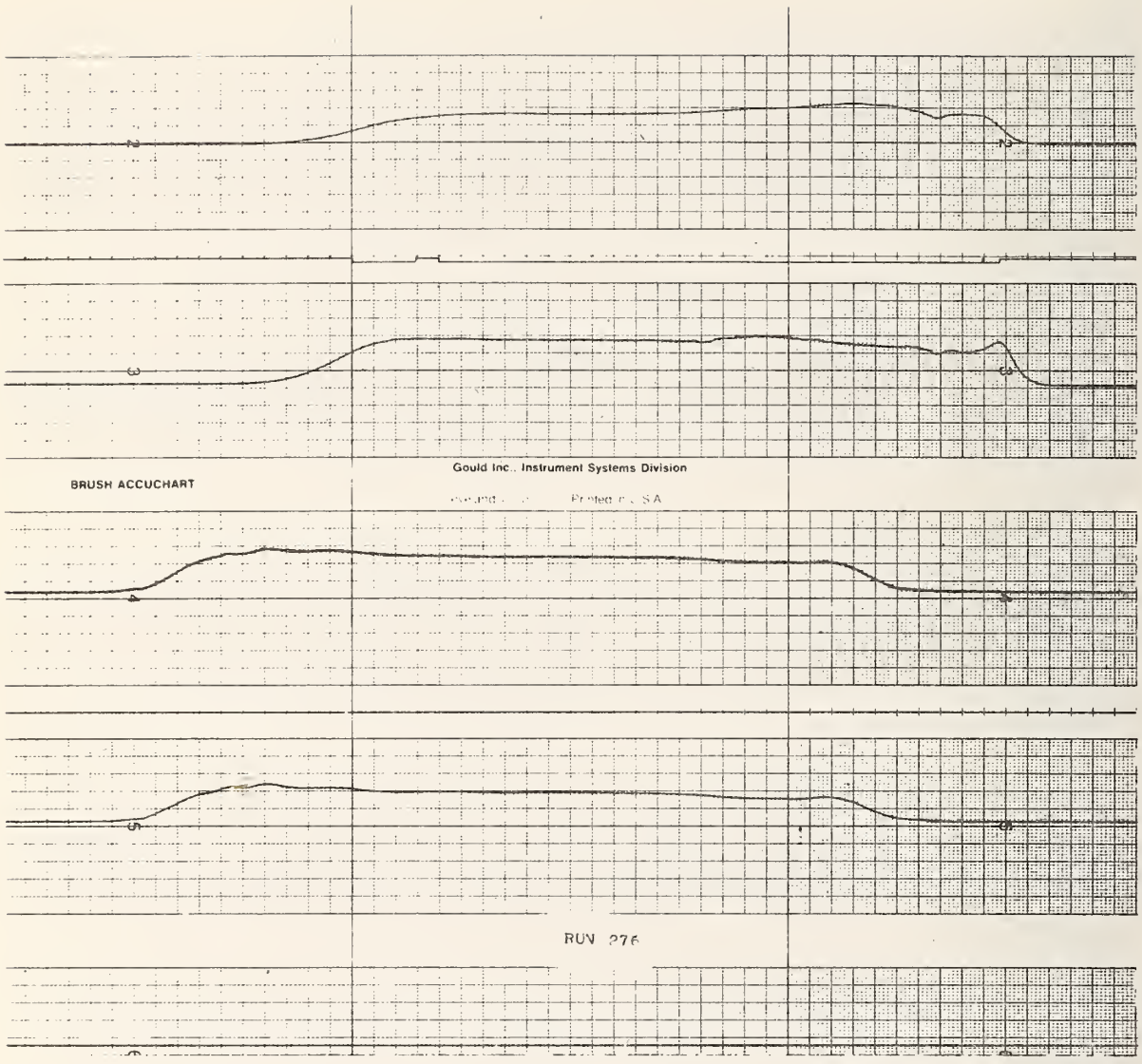
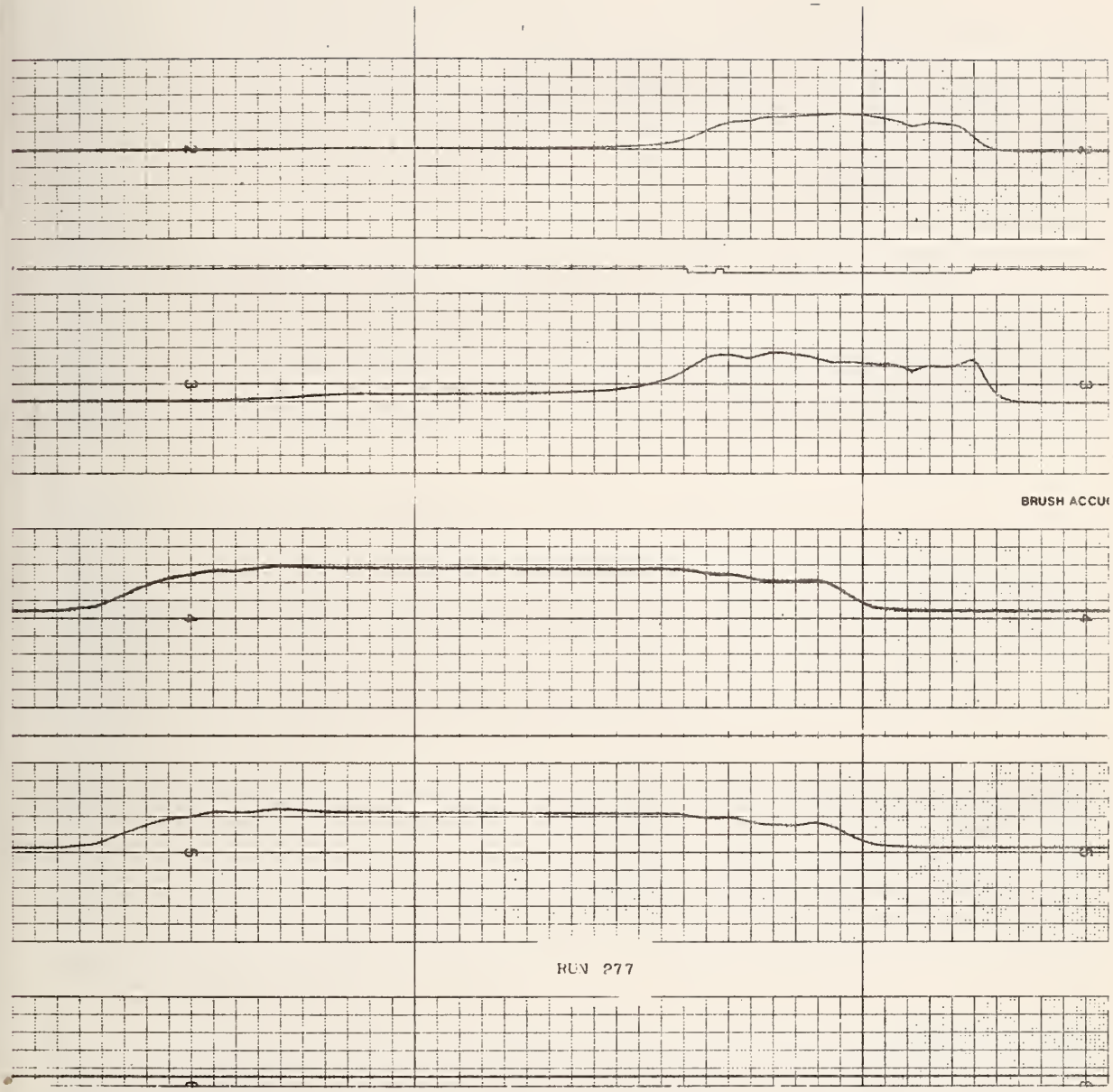
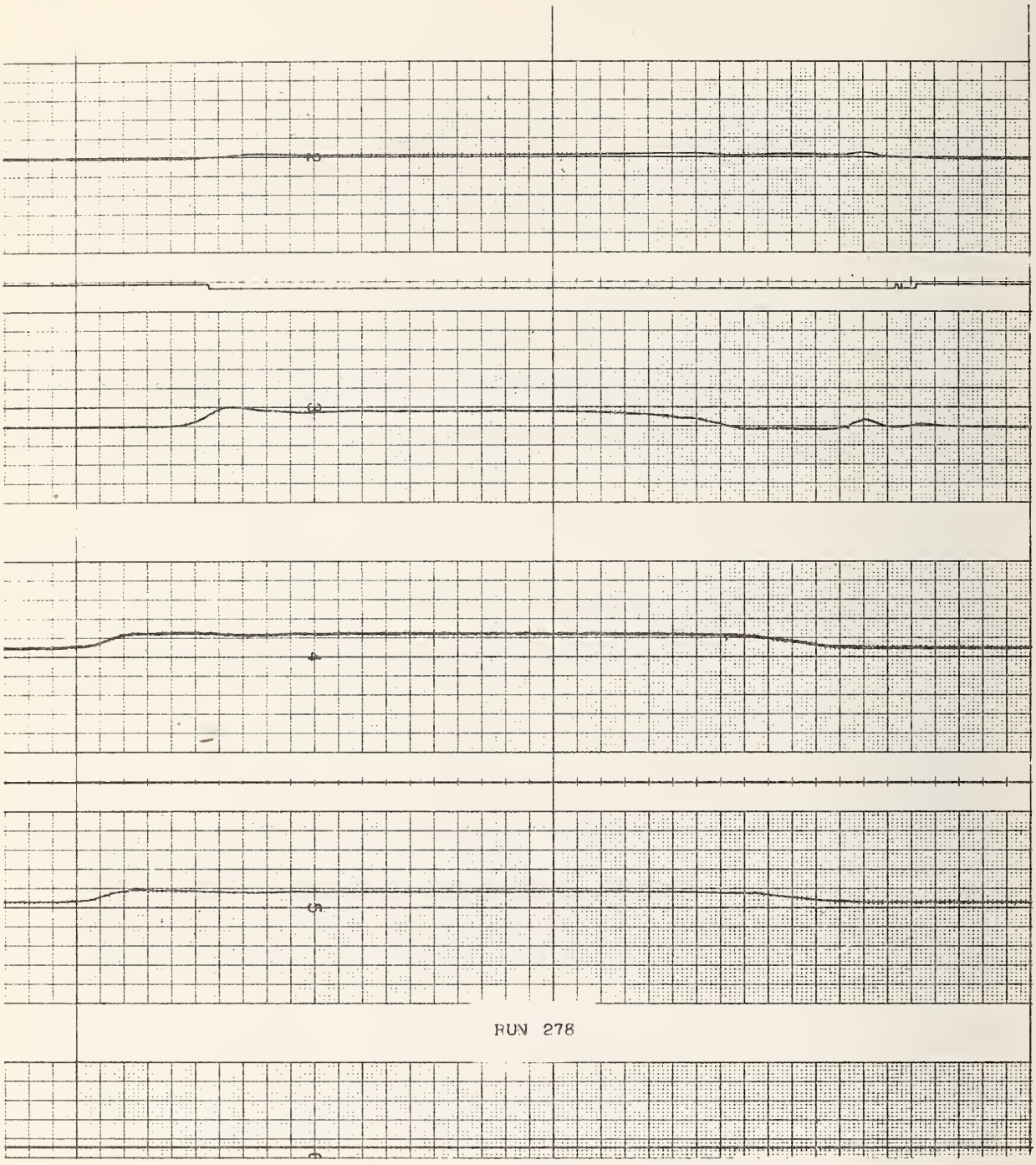
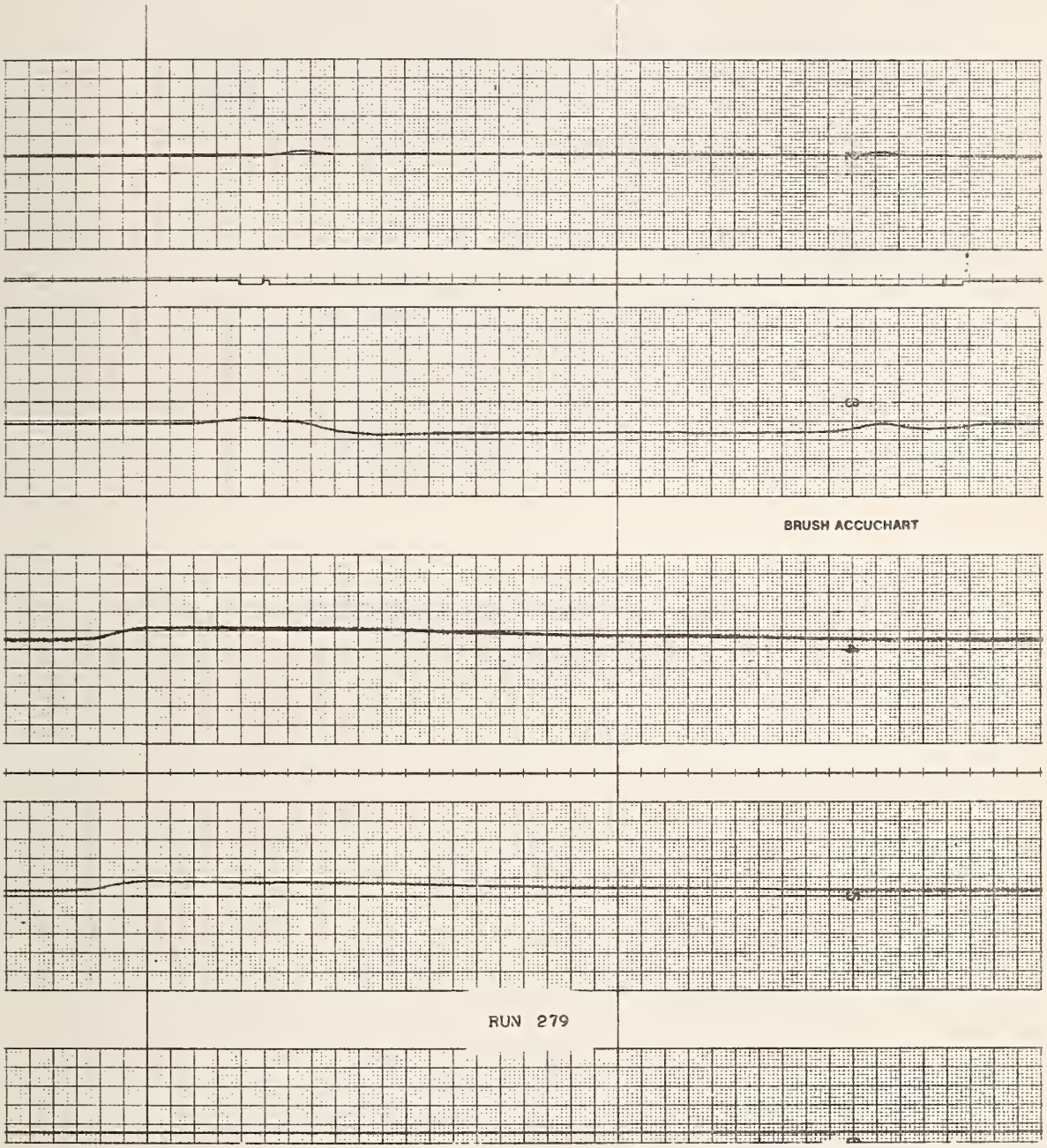
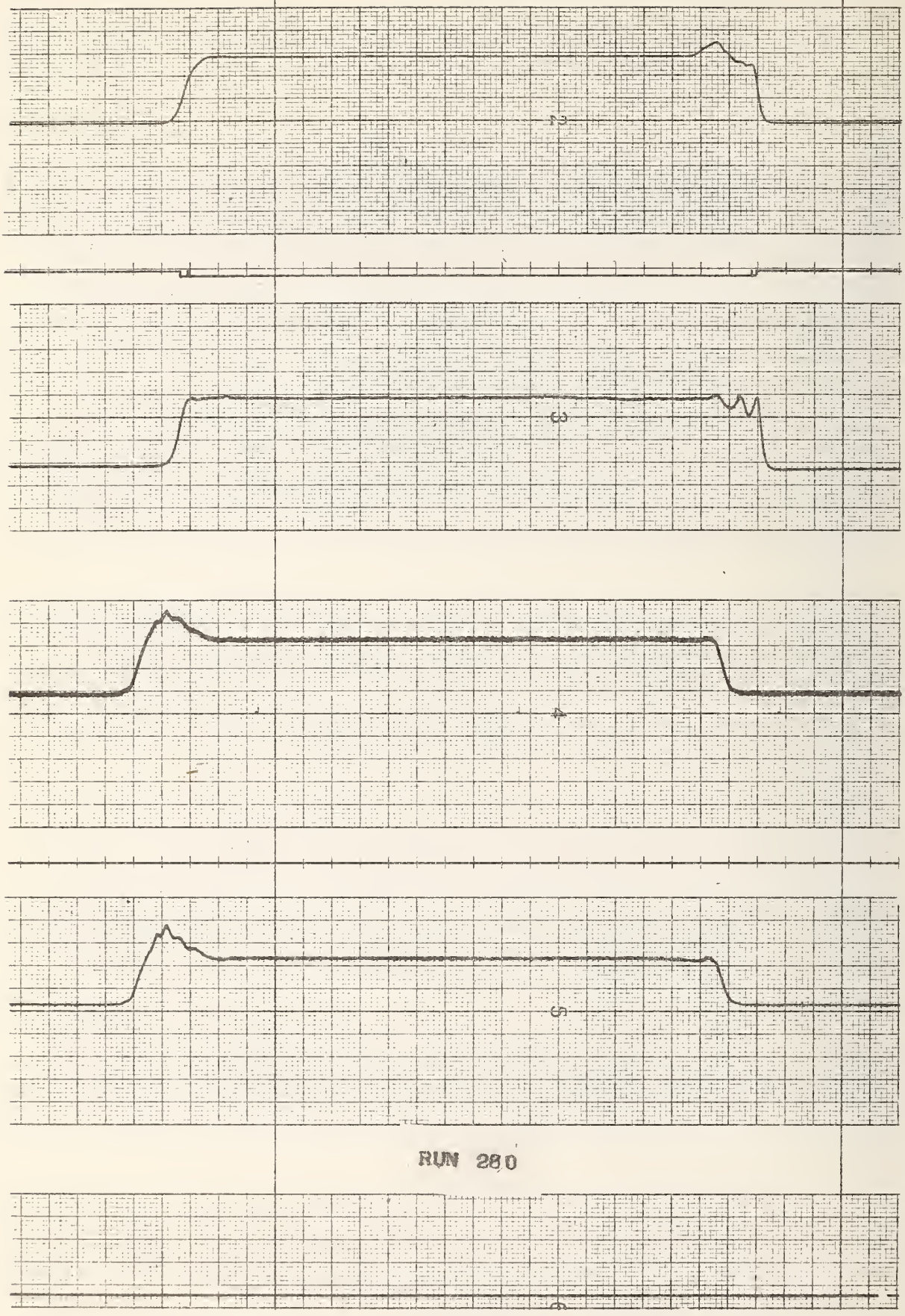

BRUSH ACCUCHART
Gould Inc., Instrument Systems Division
RUN 276


BRUSH ACCU
RUN 277



RUN 278


BRUSH ACCUCHART
RUN 279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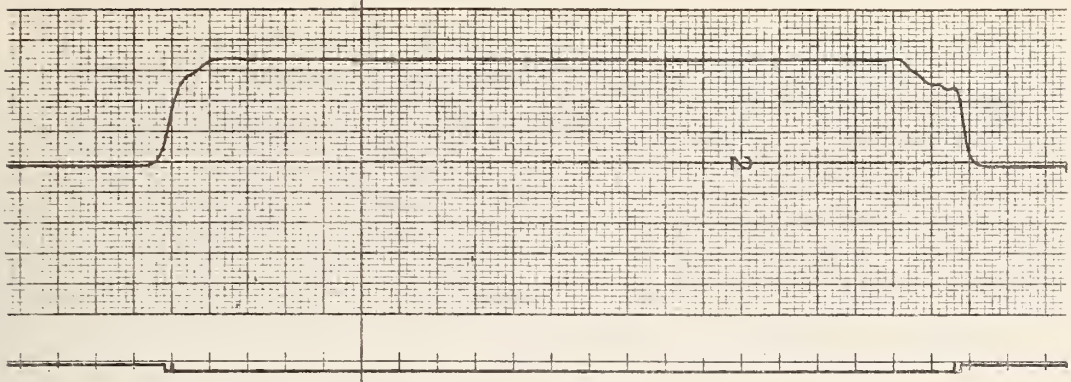

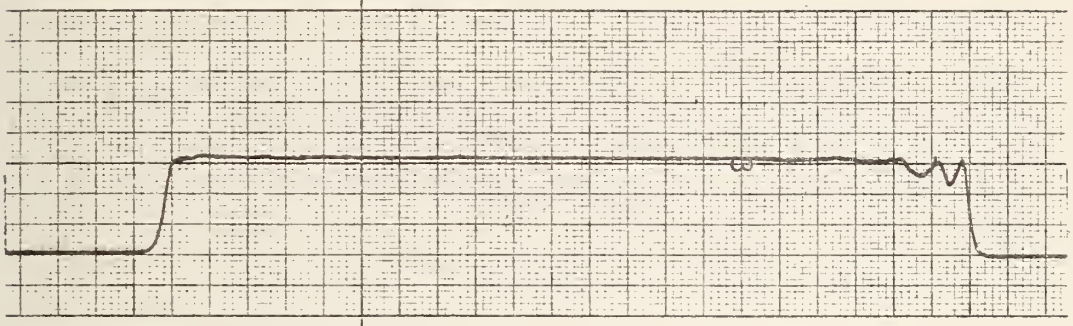

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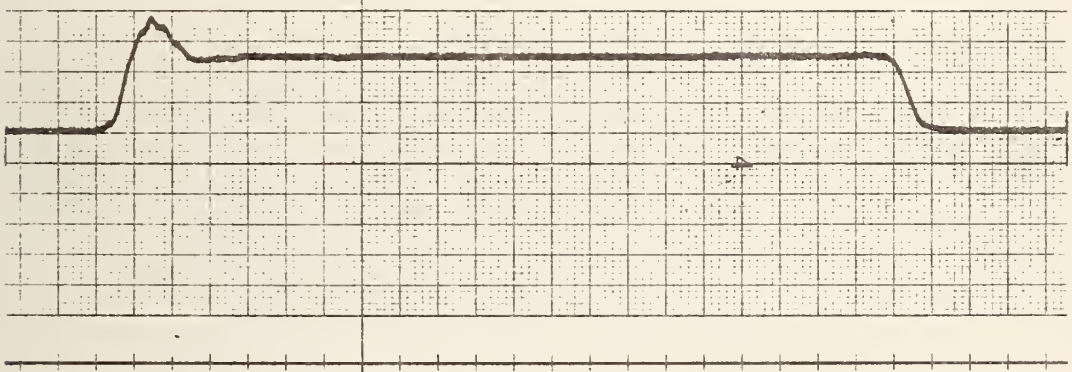

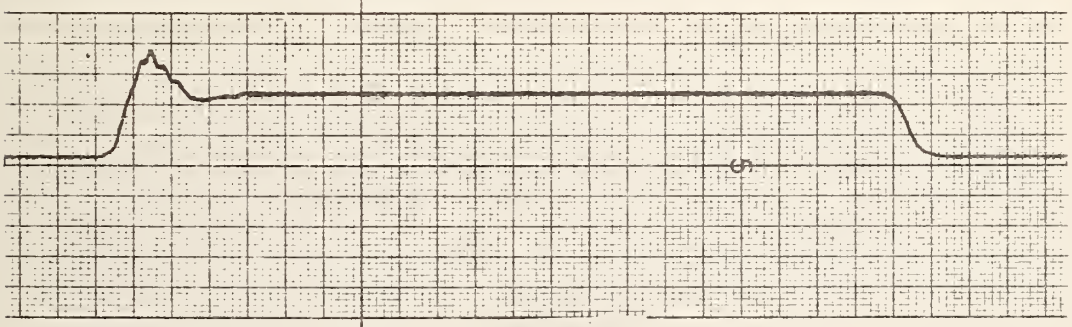

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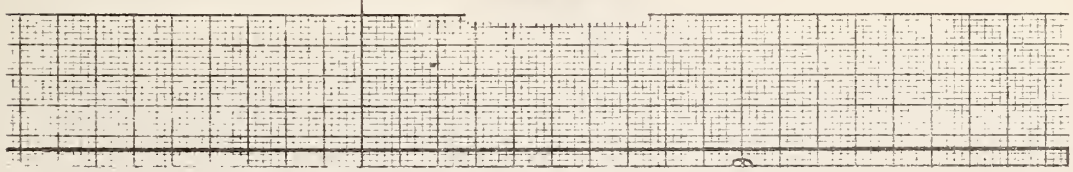

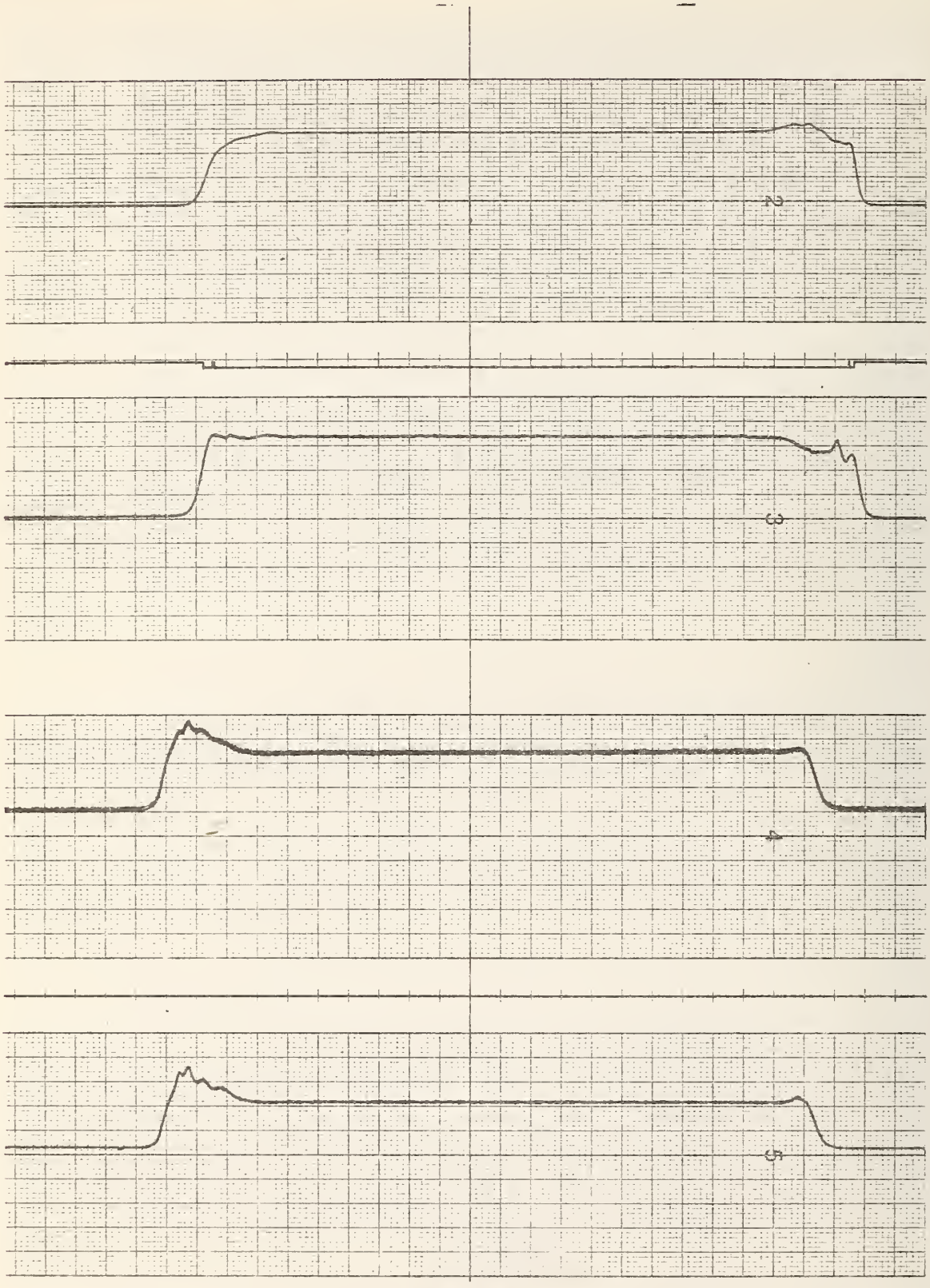

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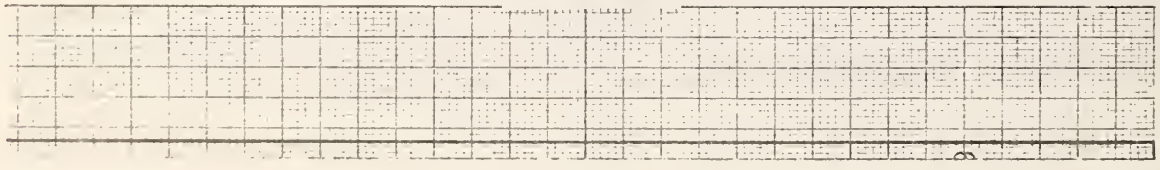

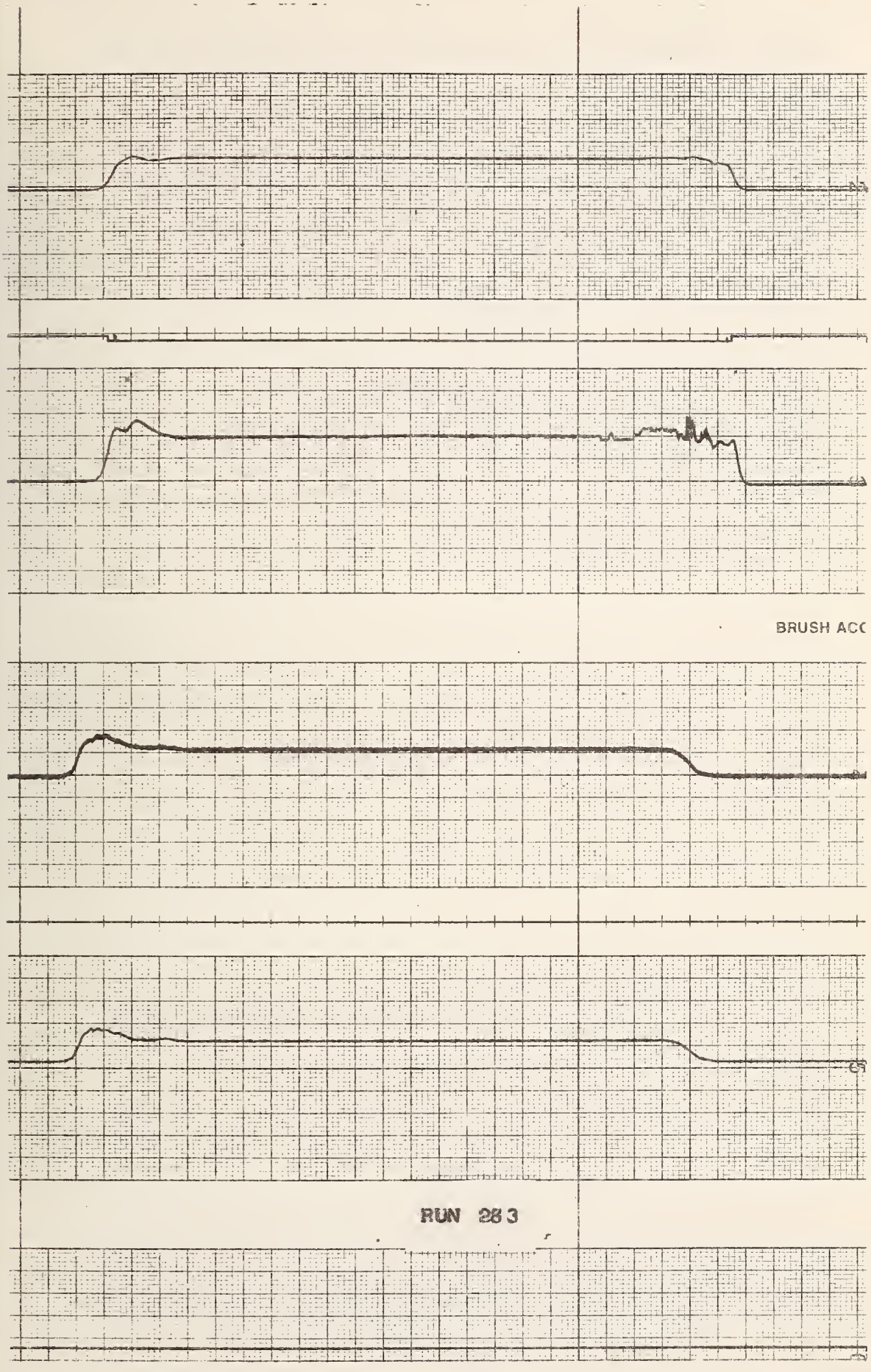
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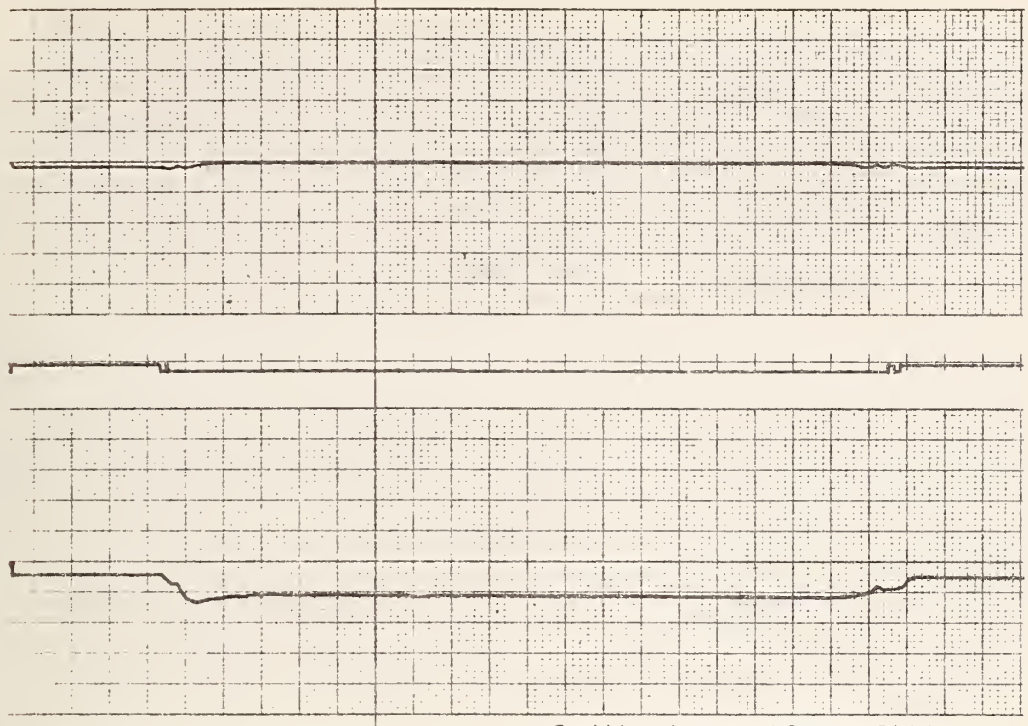

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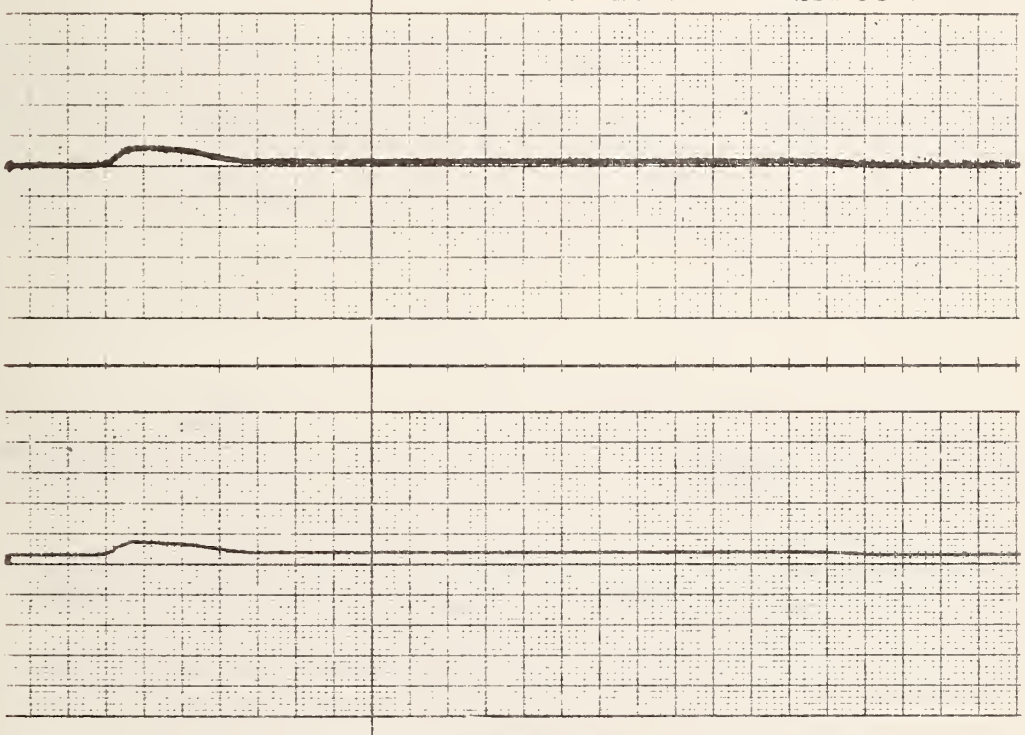

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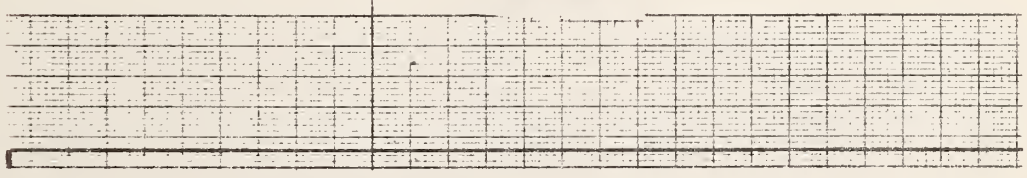

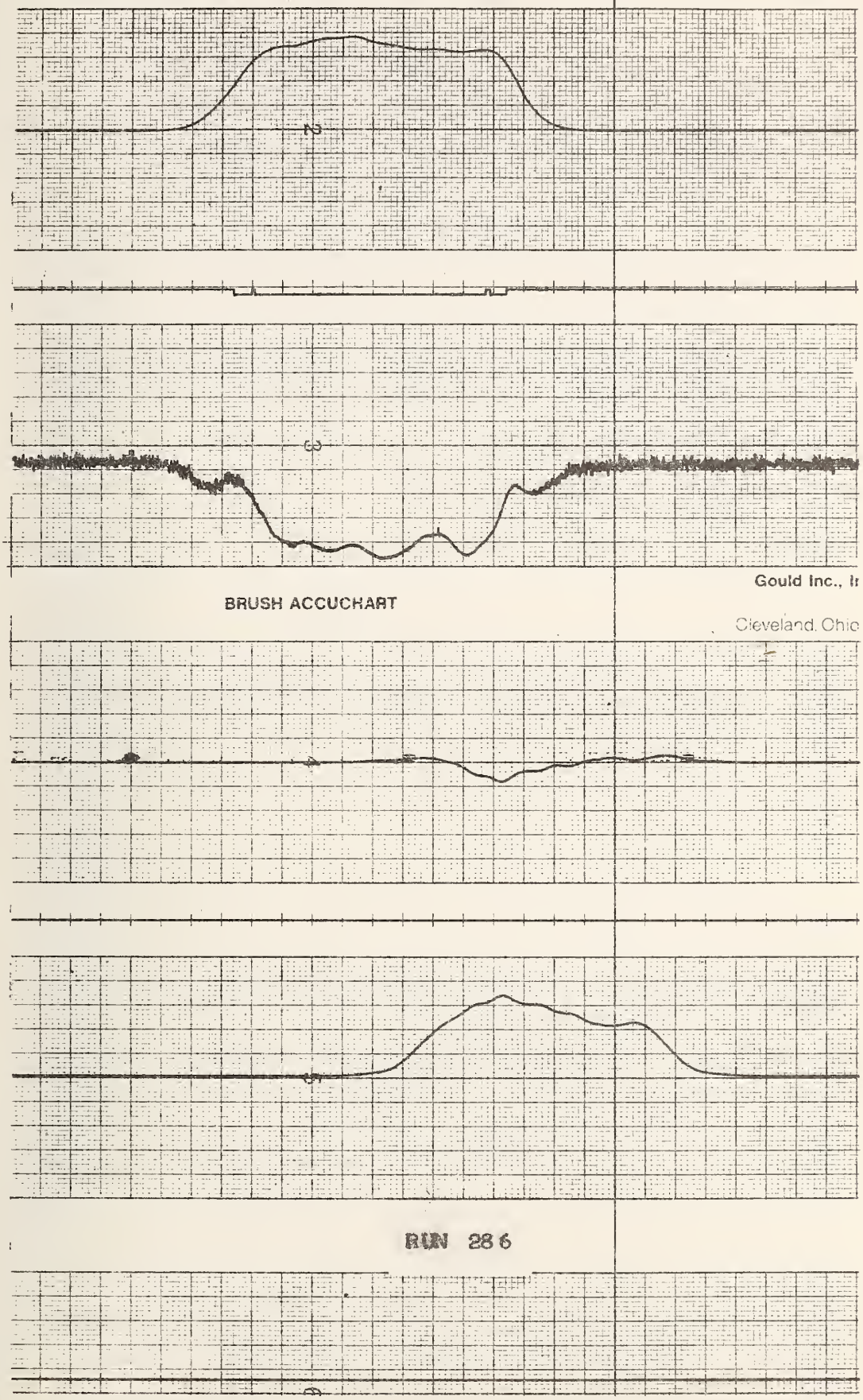
Gould Inc., I
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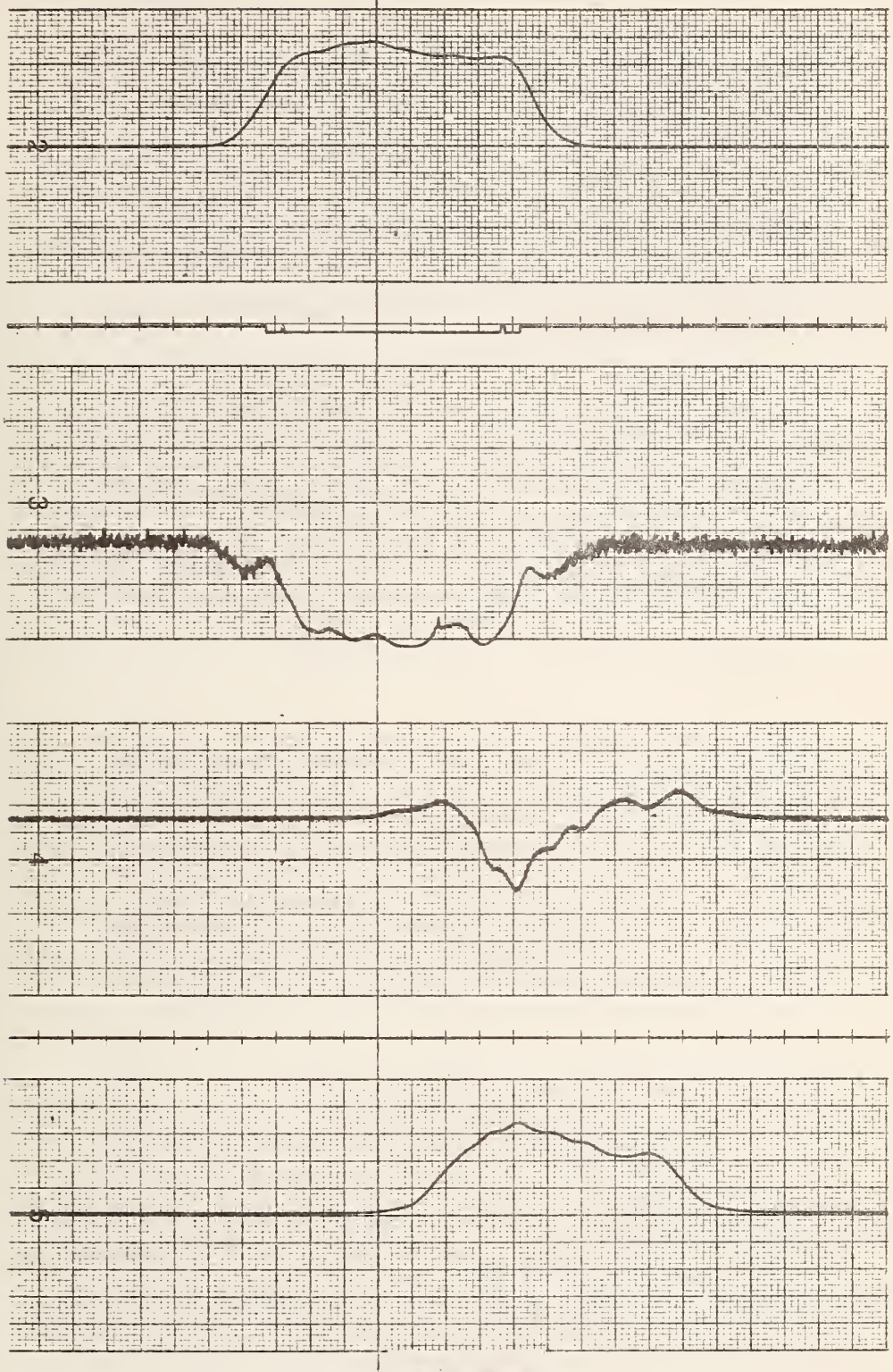
Cleveland, Ohio
RUN 286



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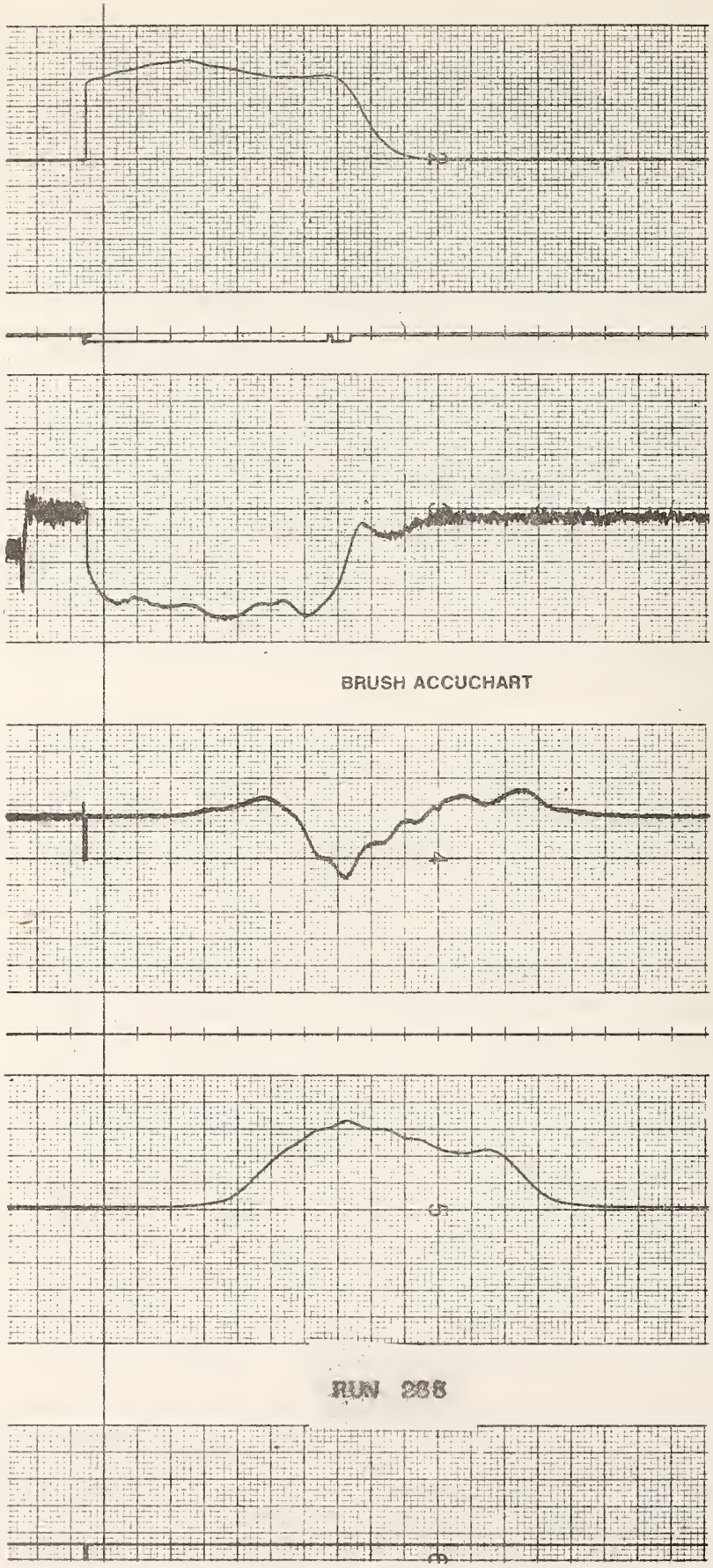

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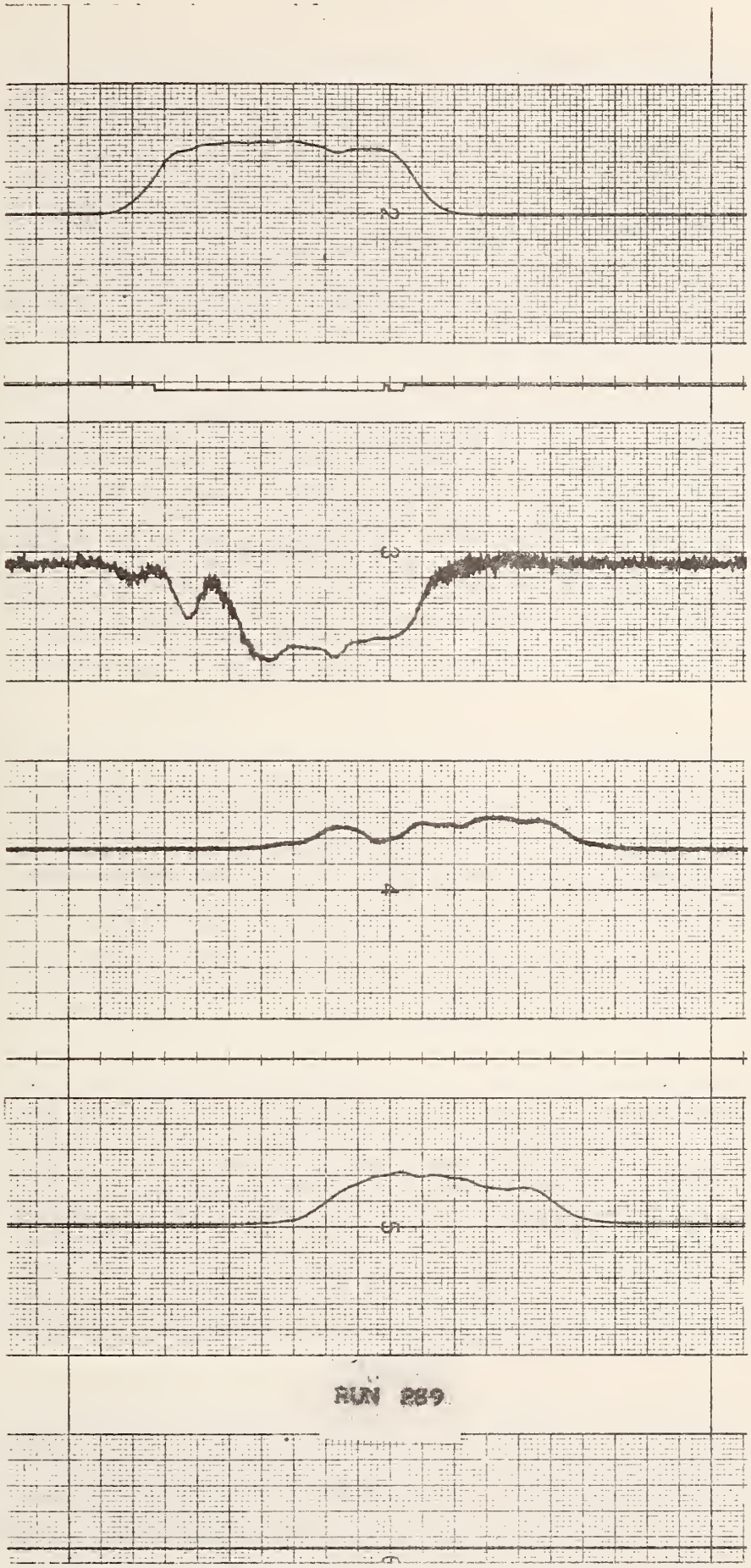
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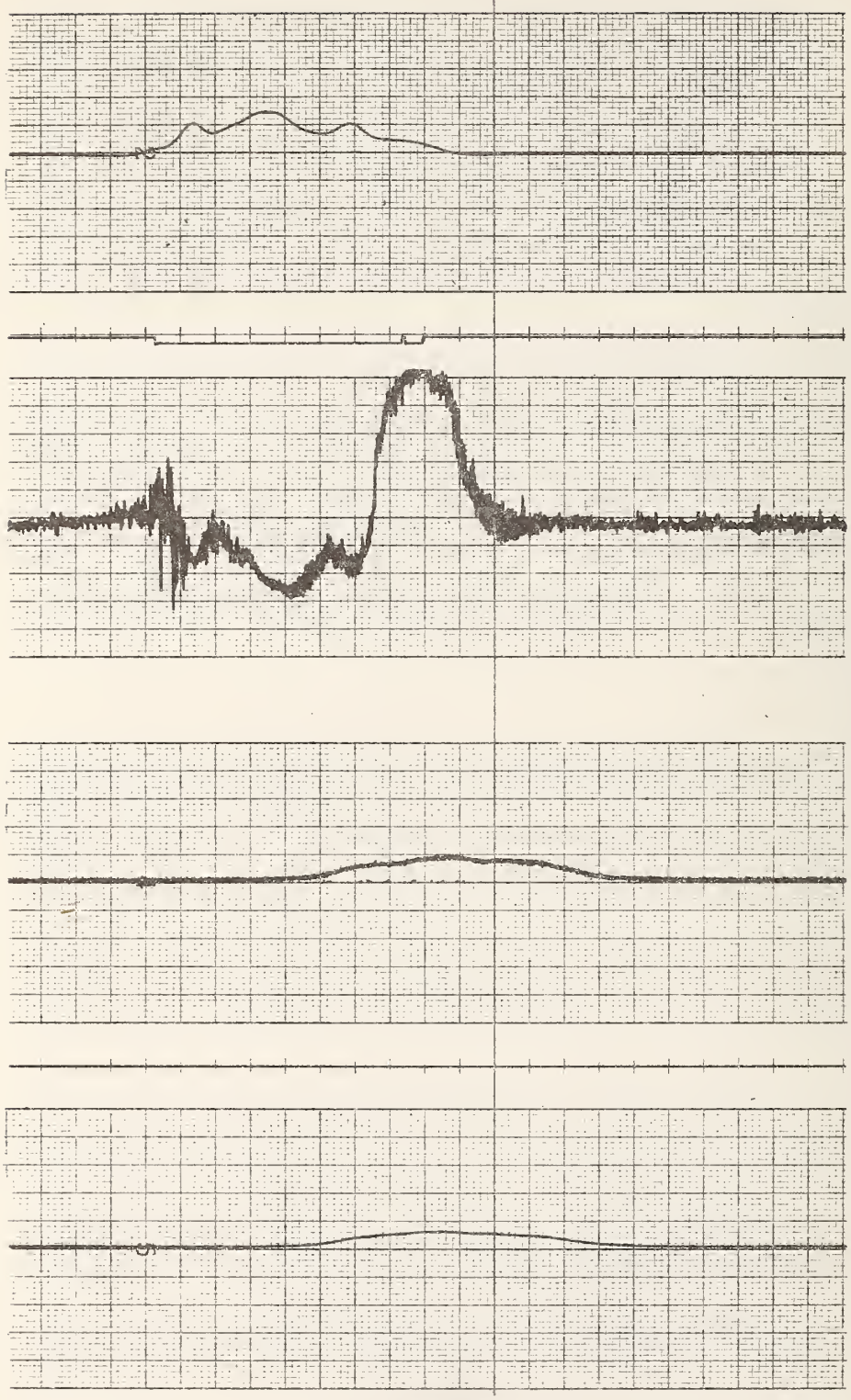

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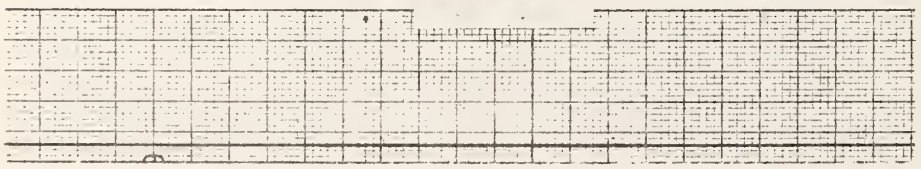

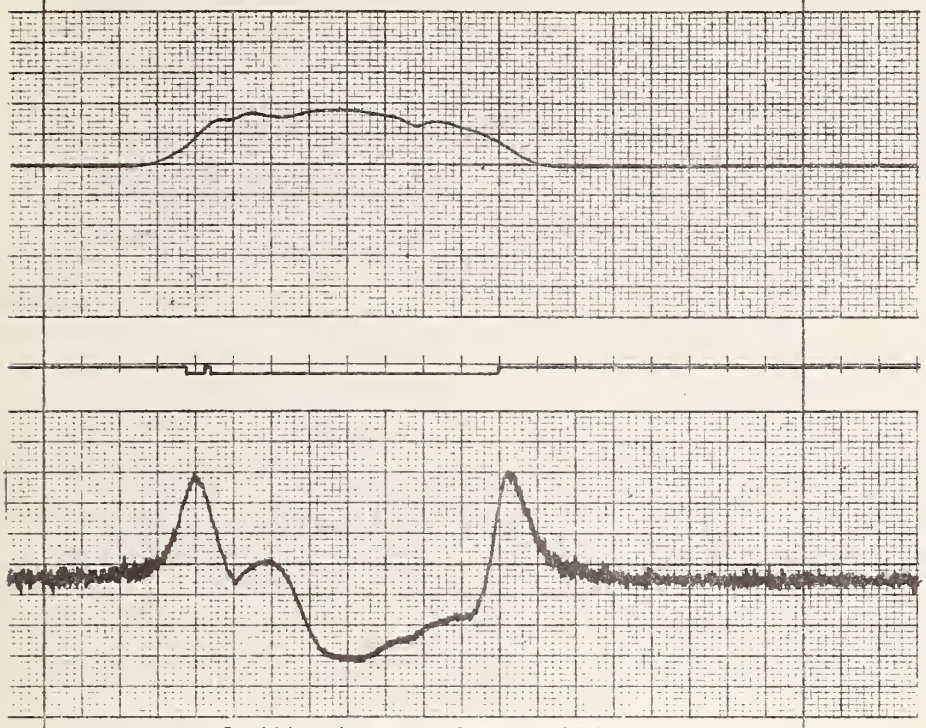

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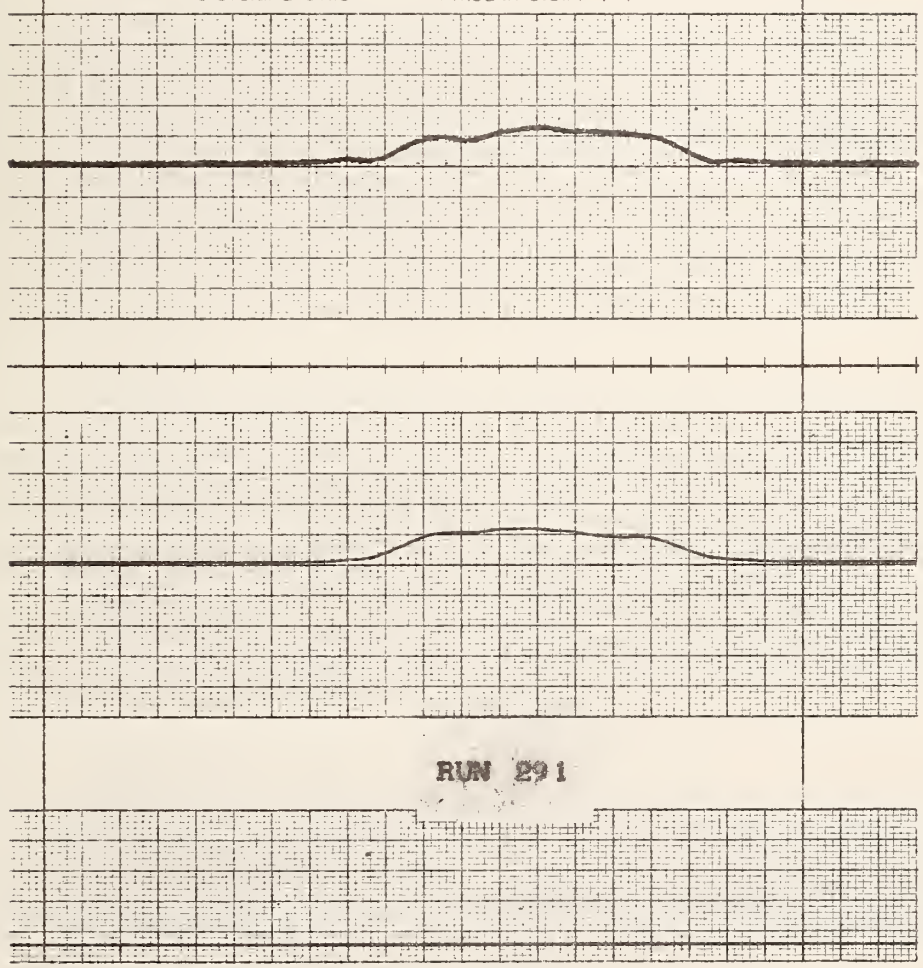

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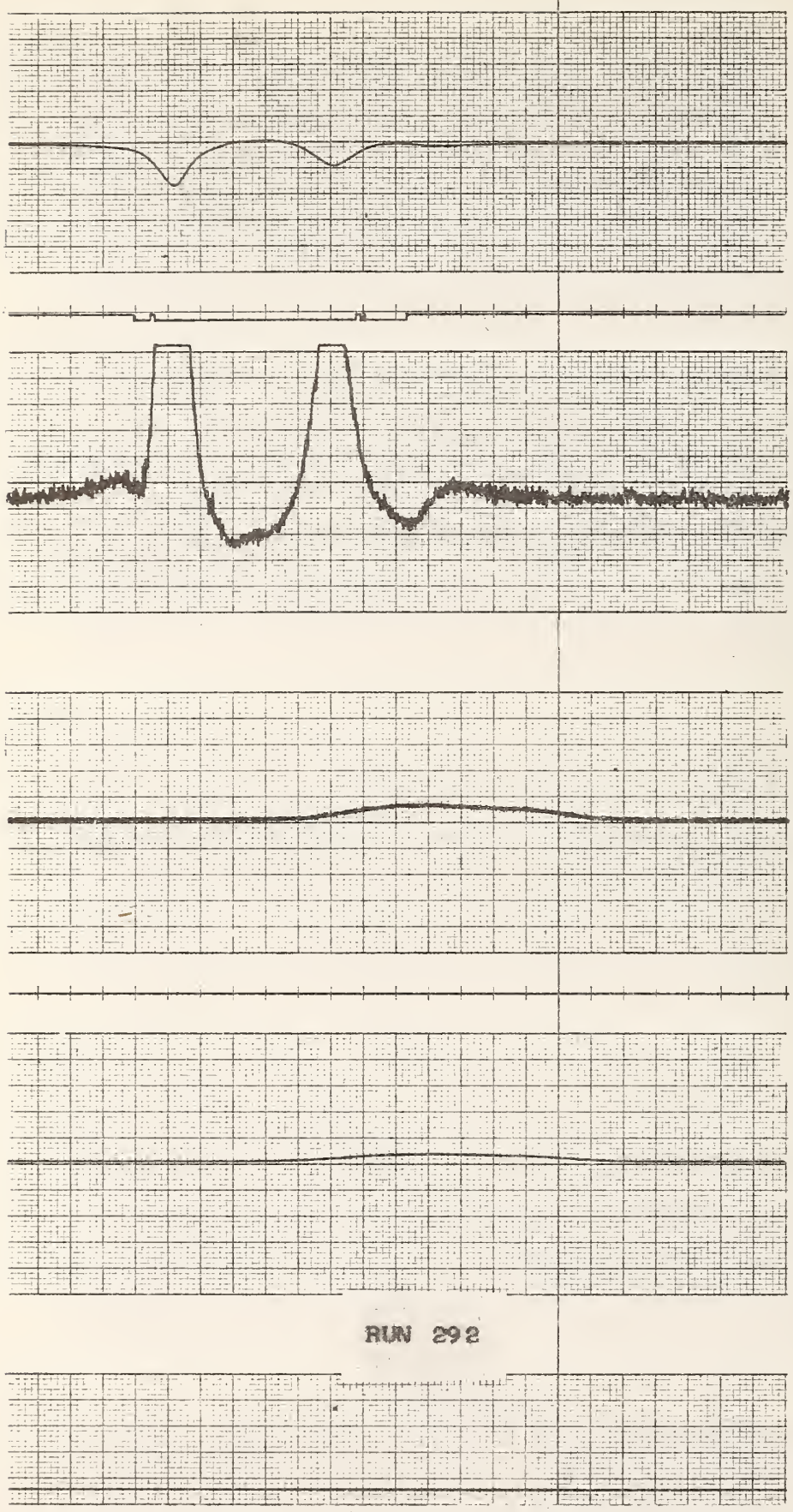

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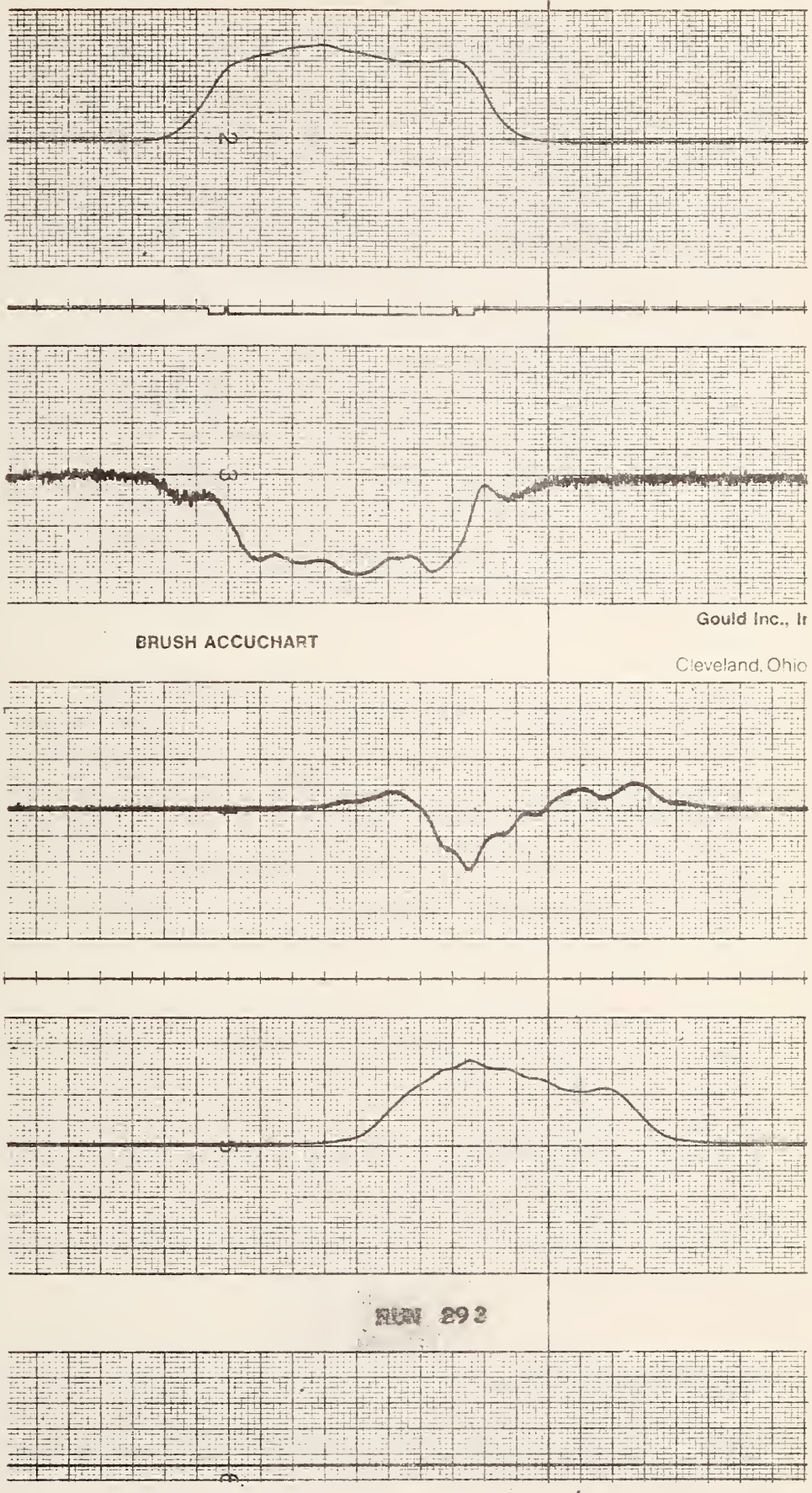
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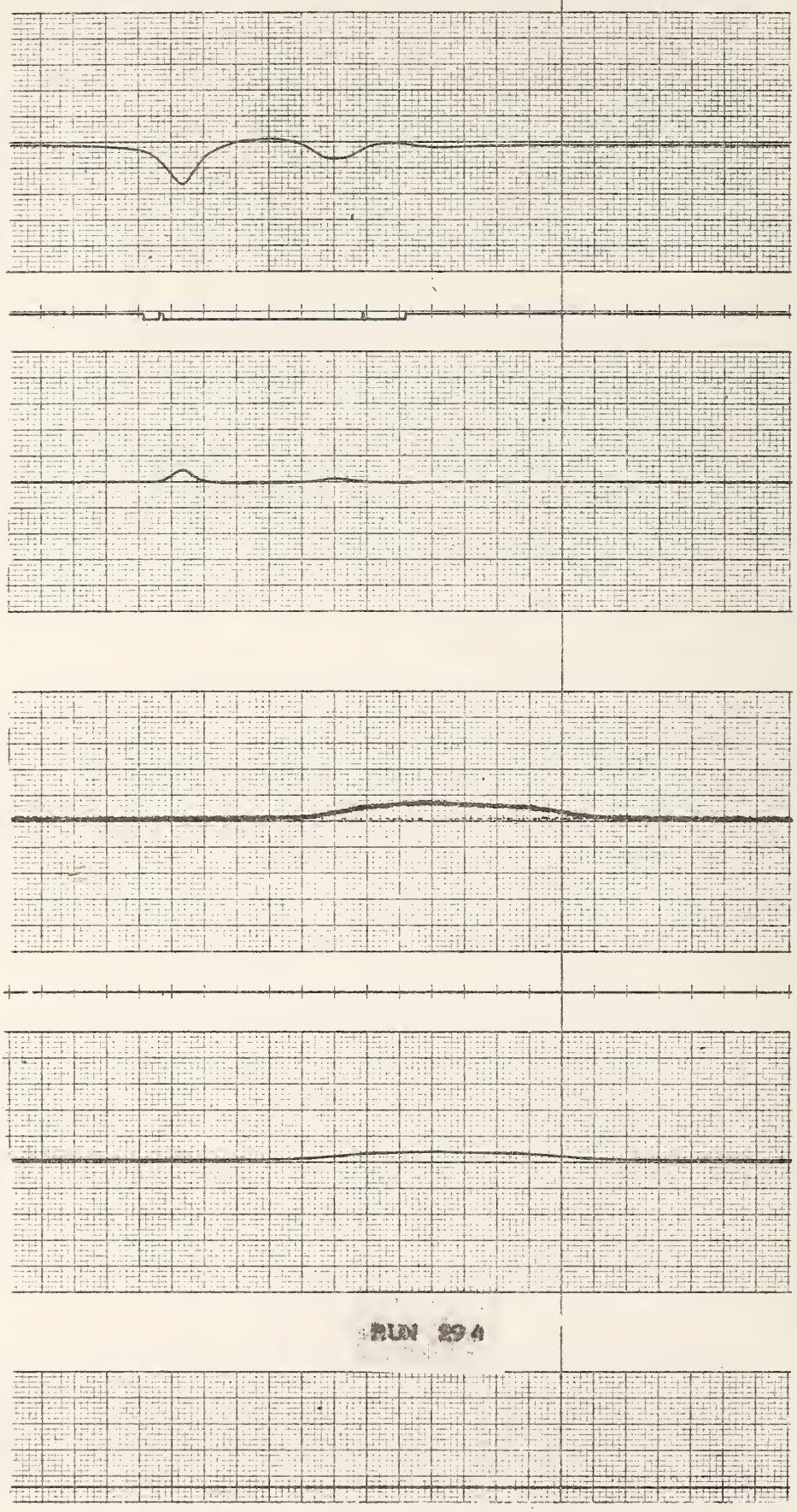
RUN 292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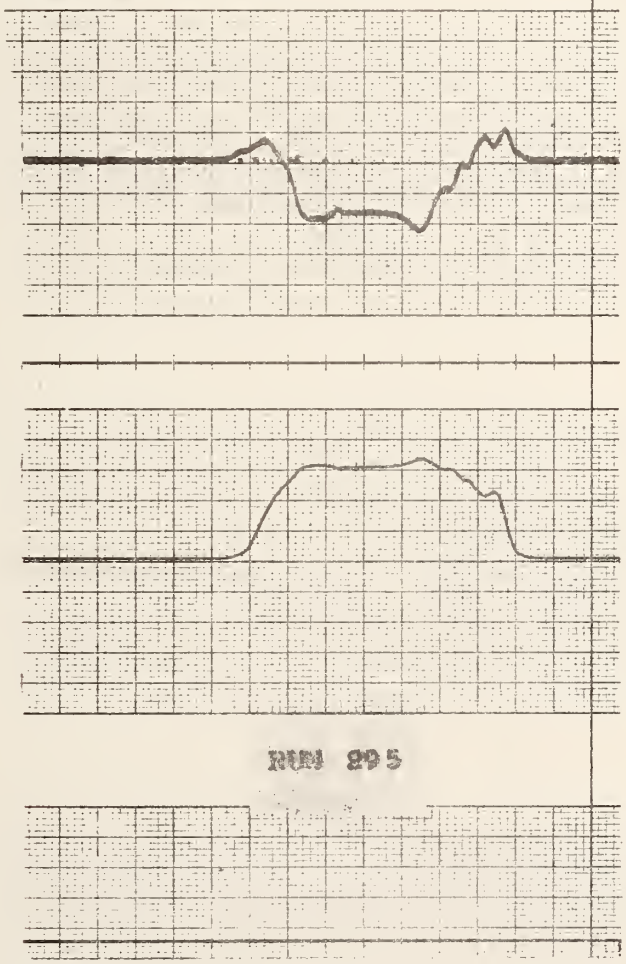

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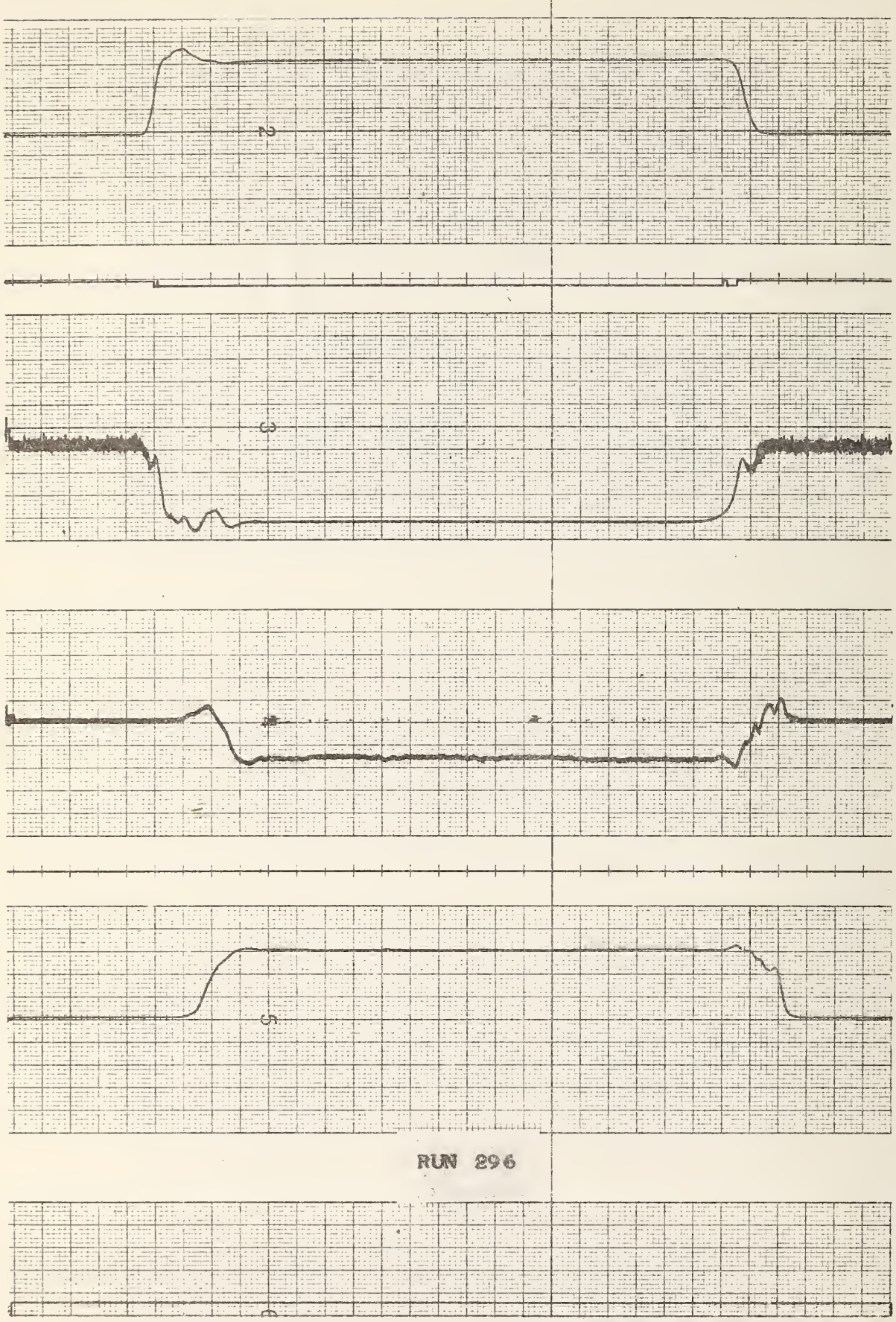

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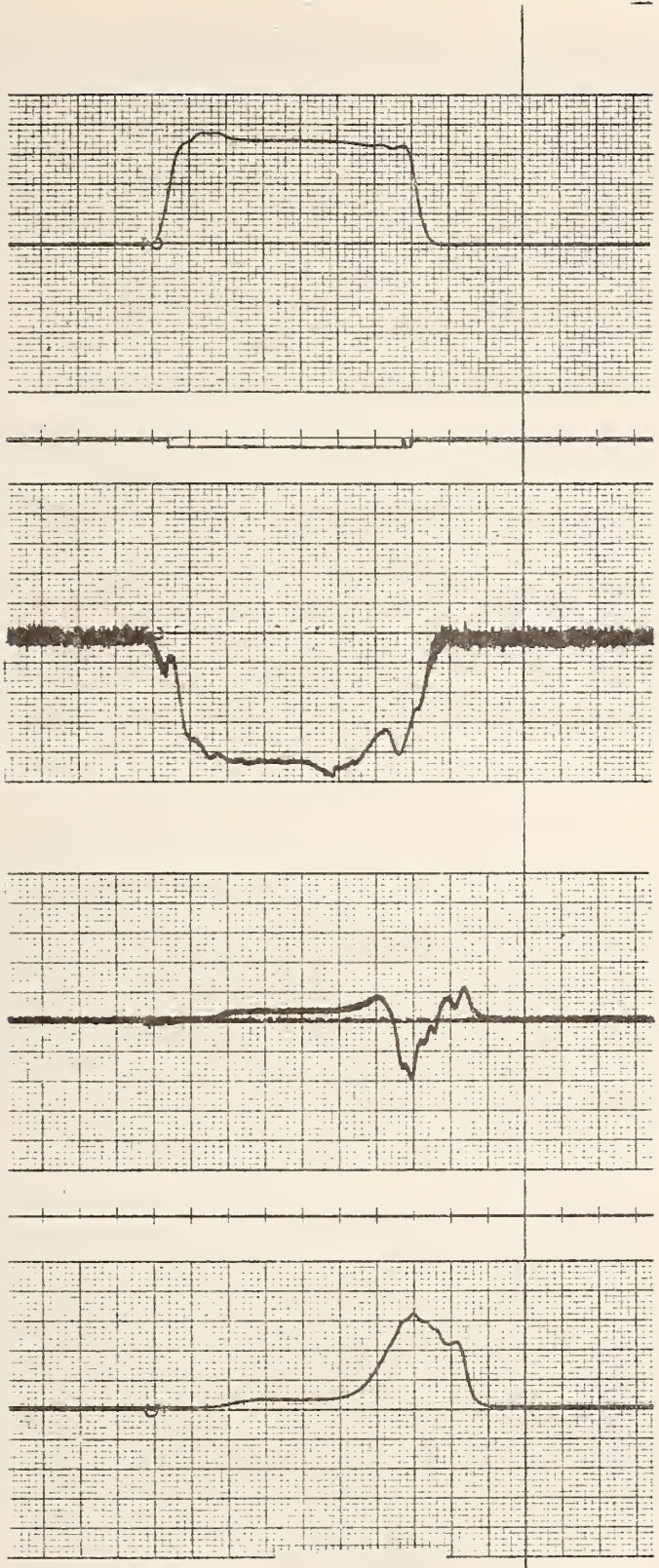

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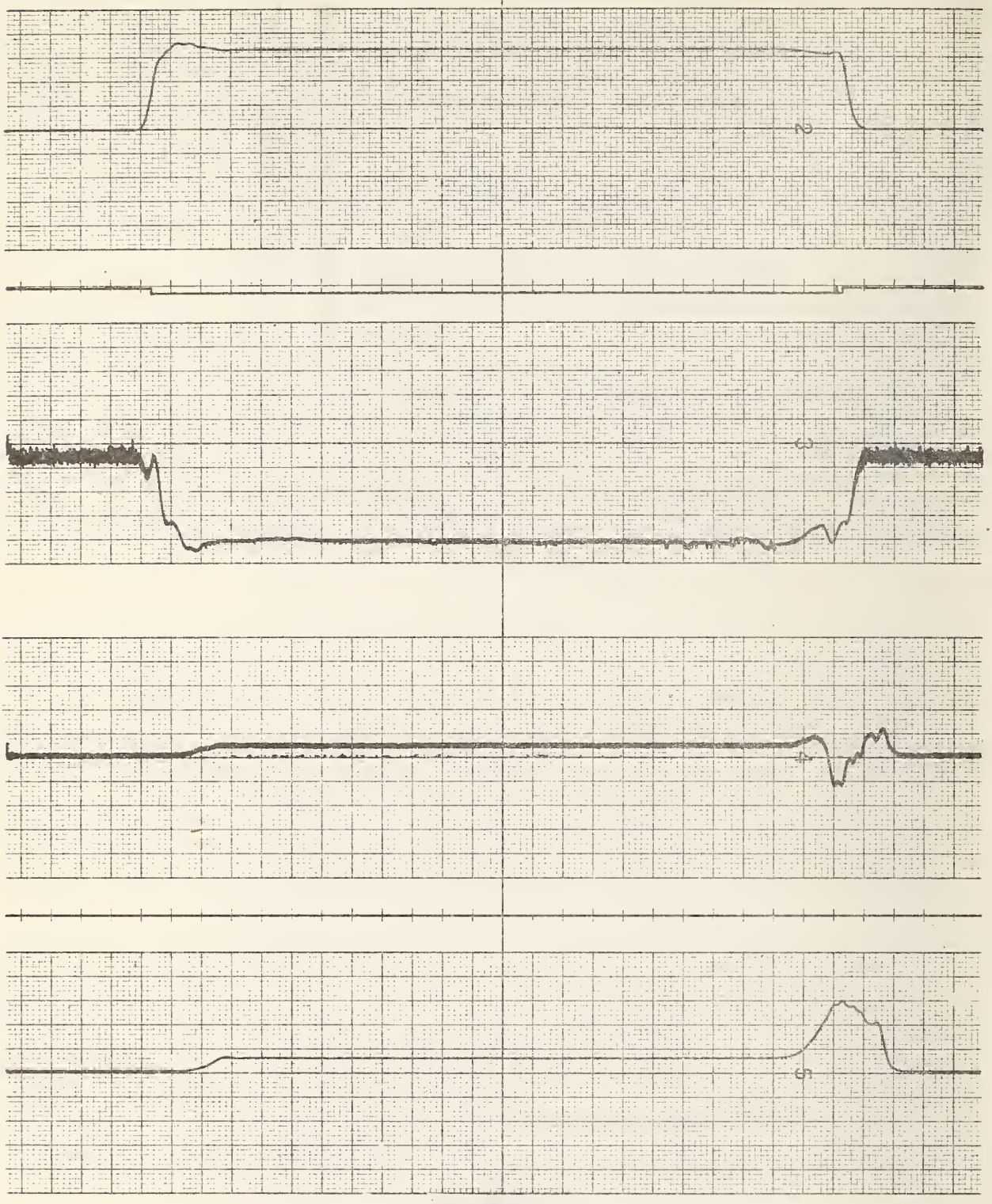

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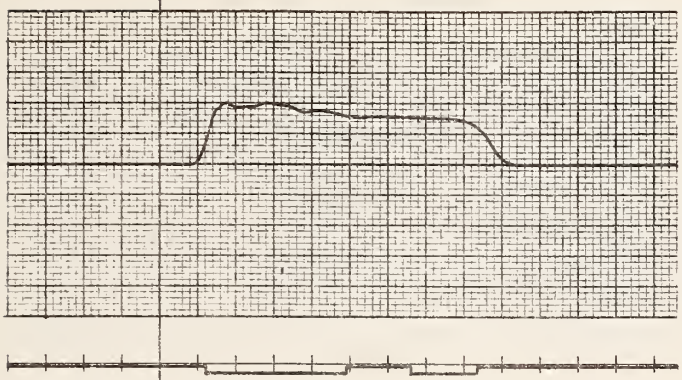

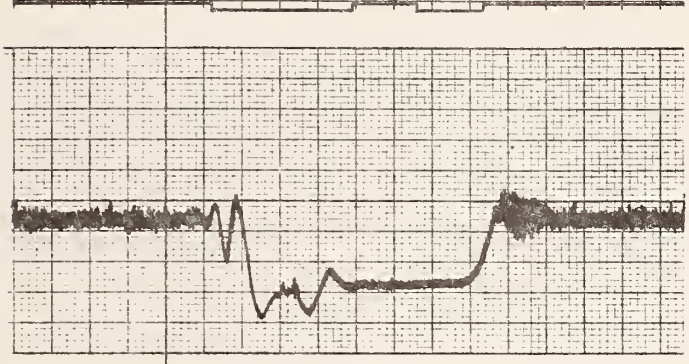

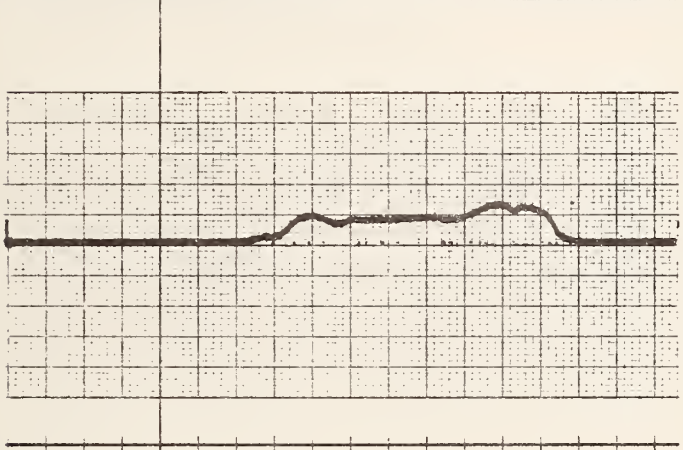

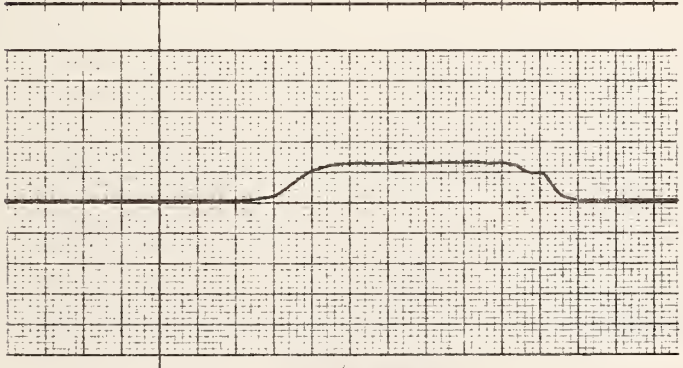

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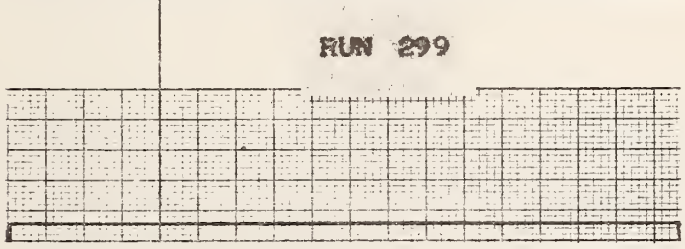

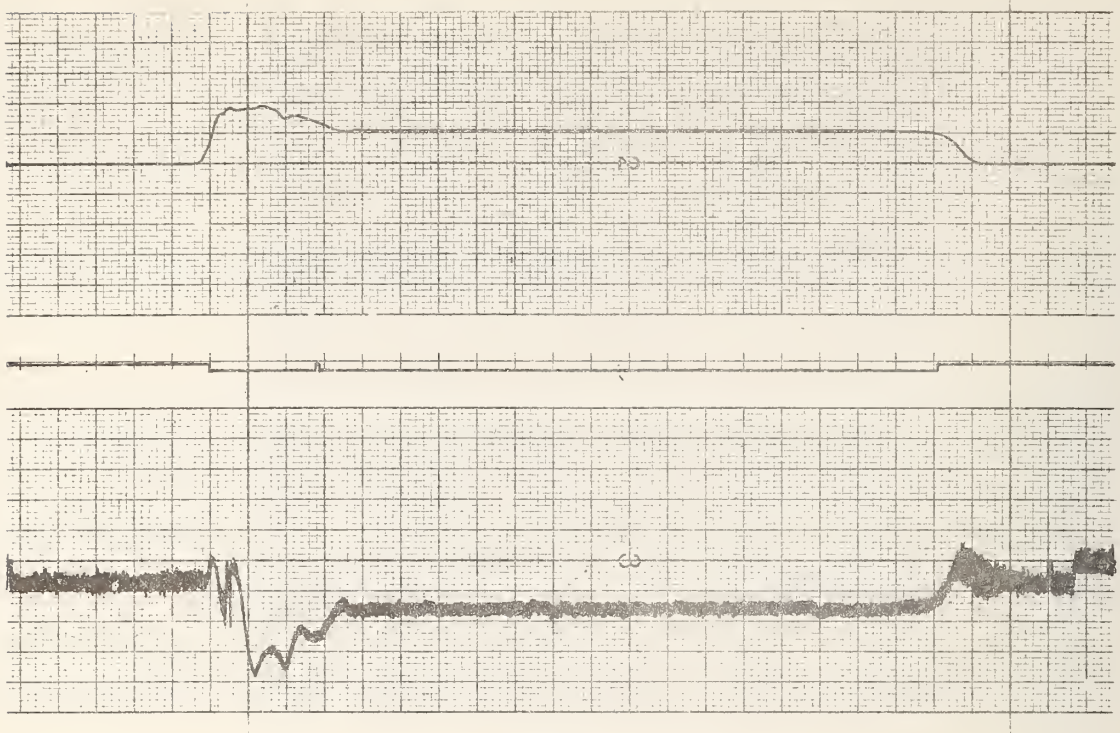

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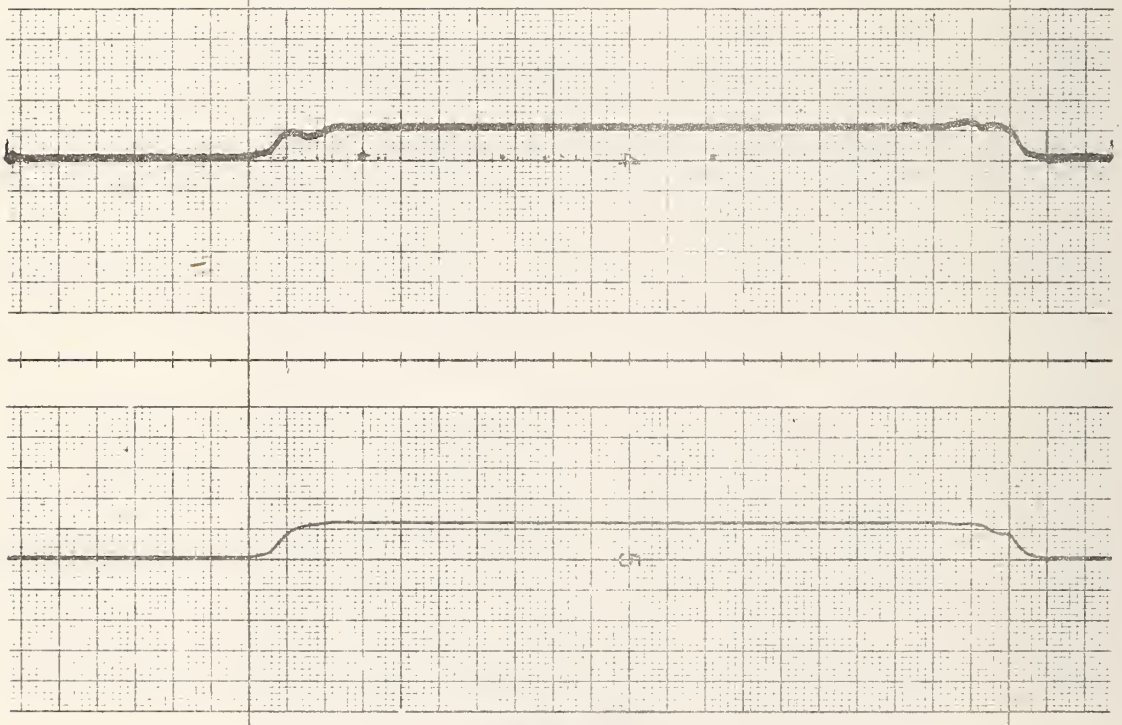

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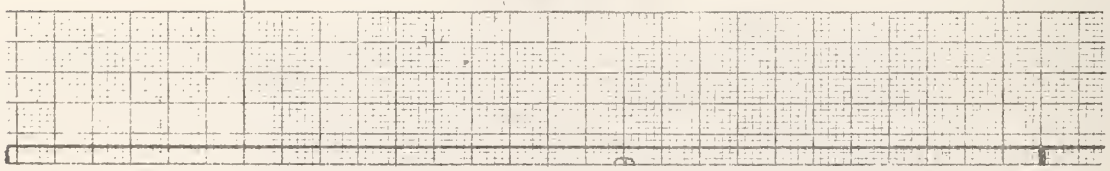

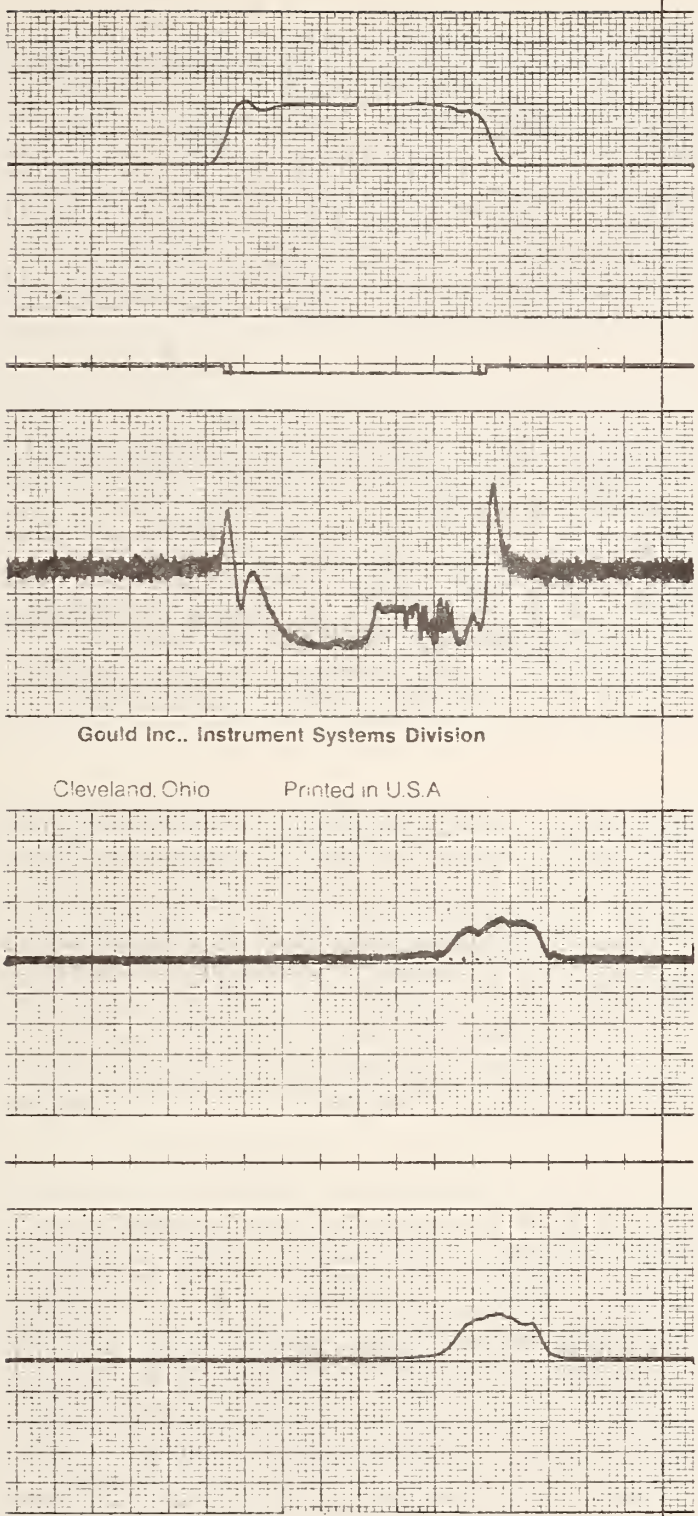

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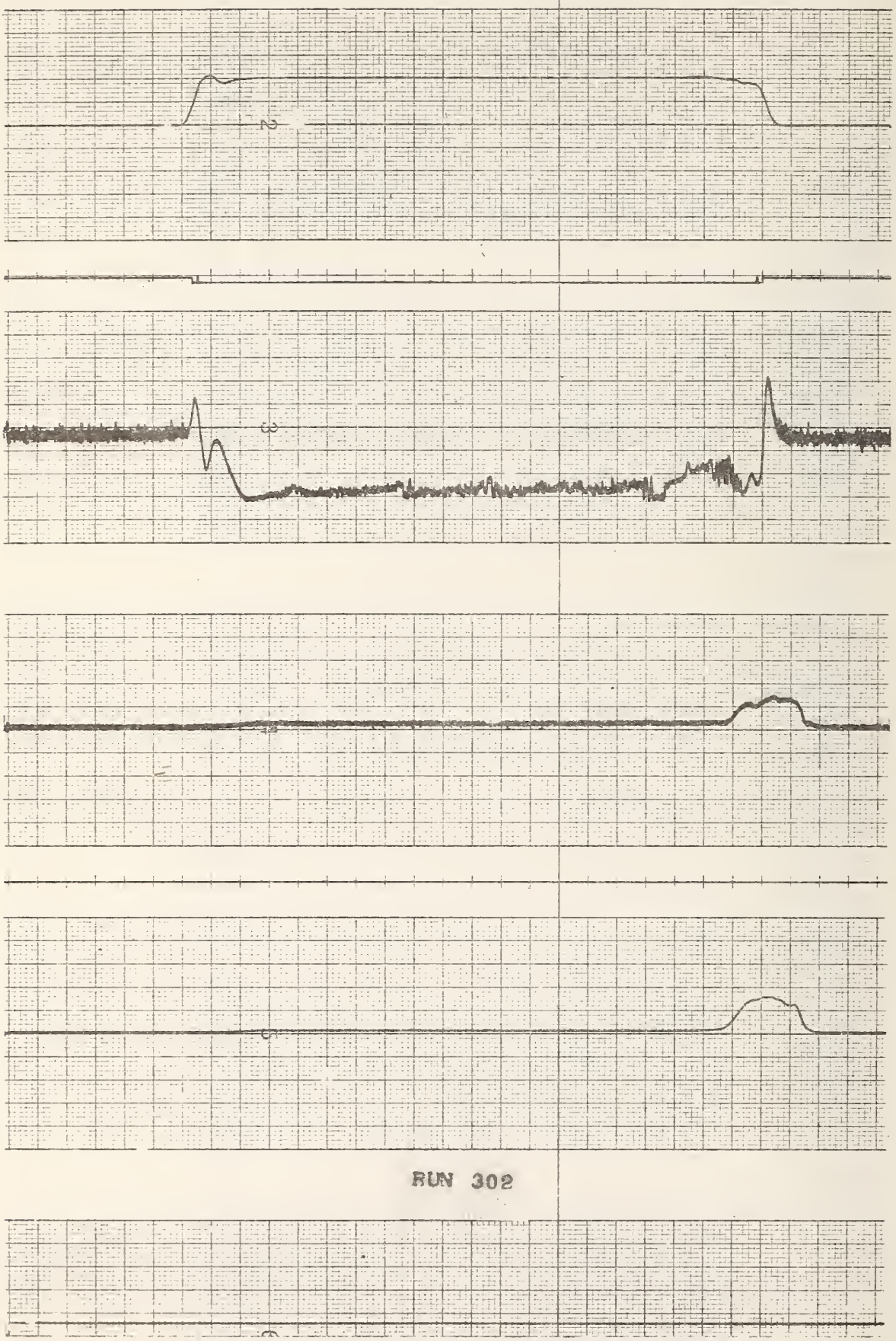

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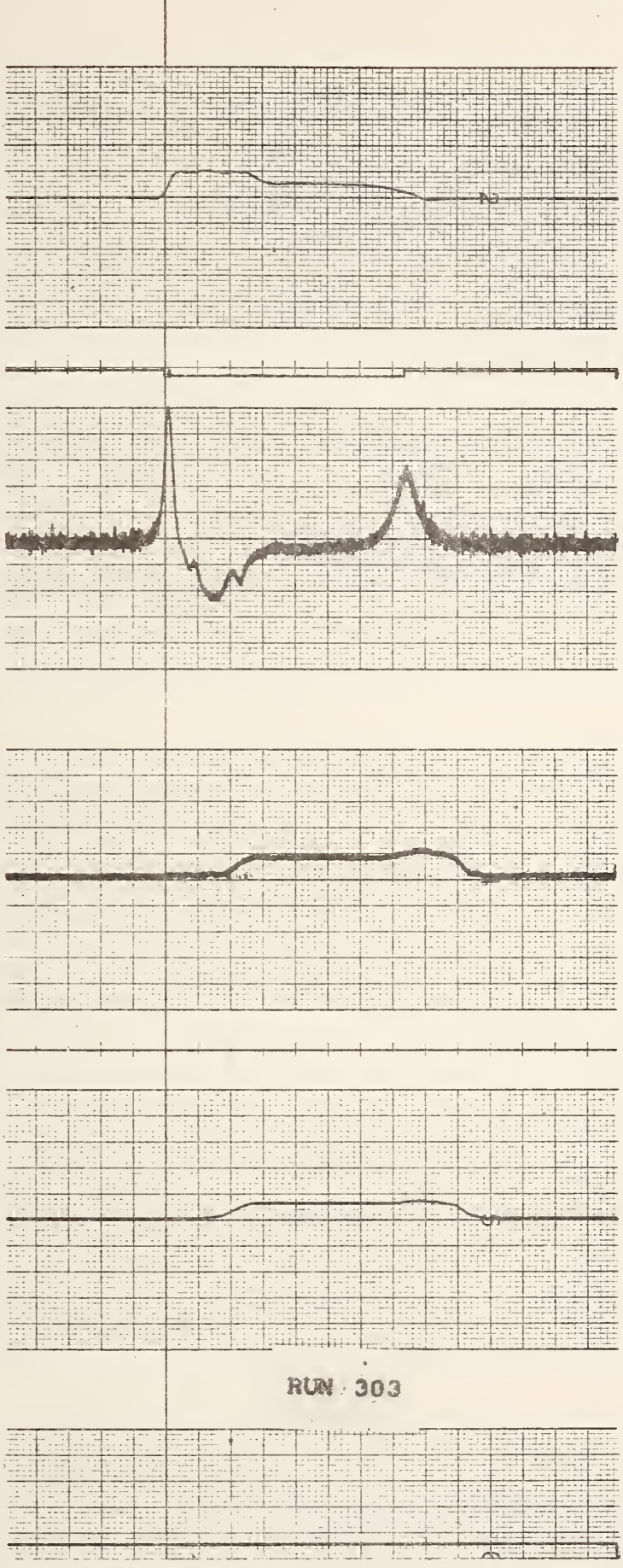
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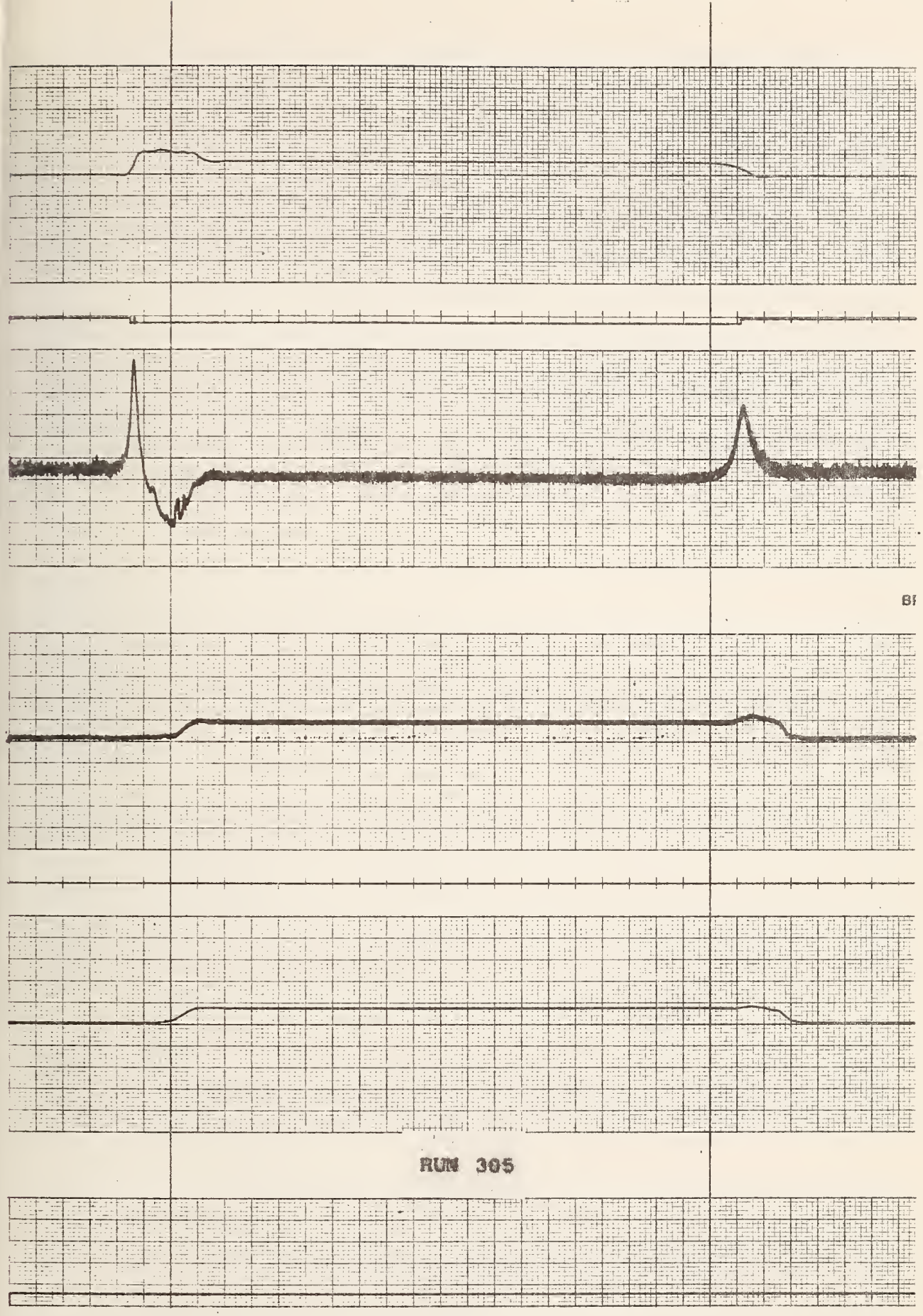
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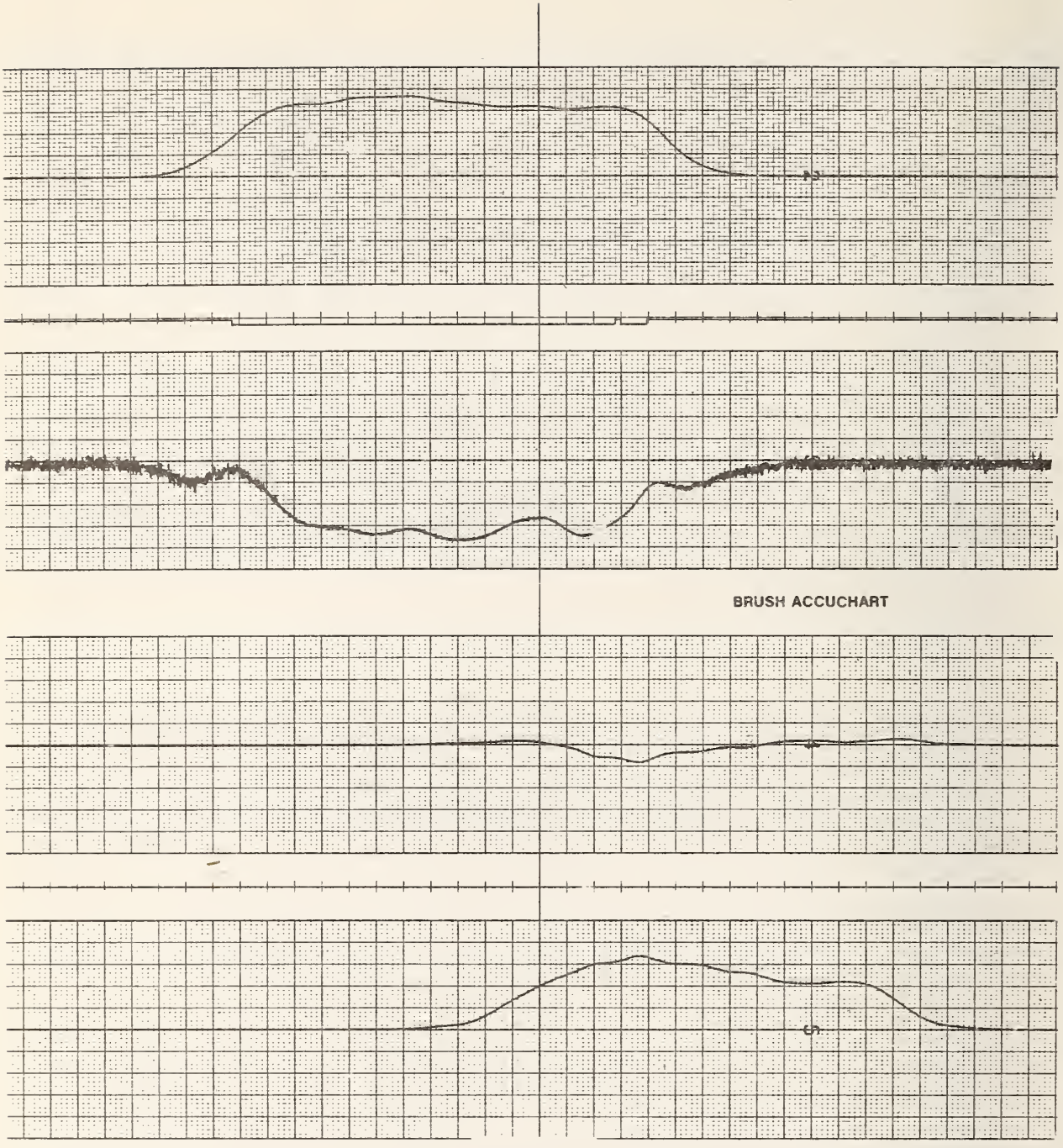

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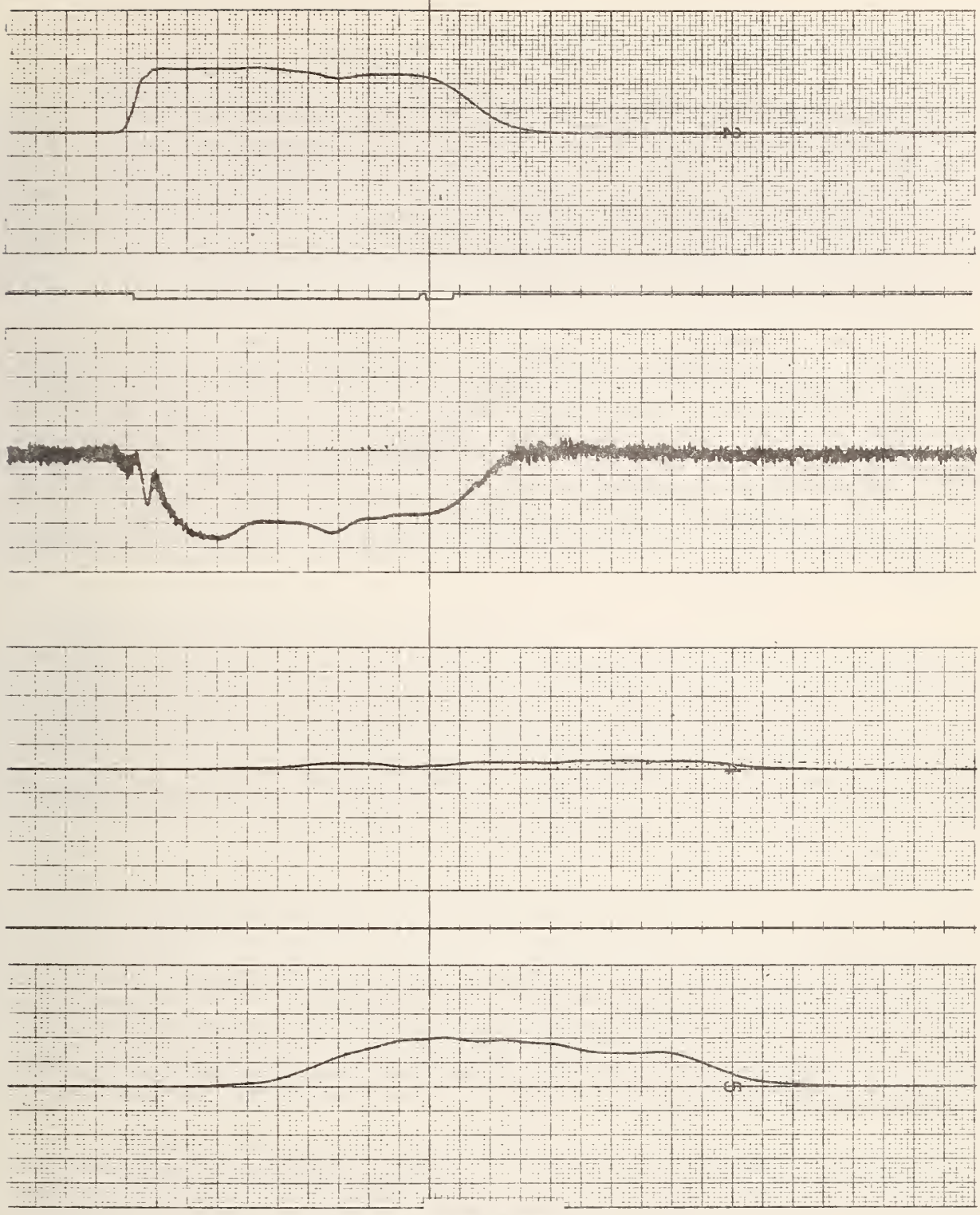

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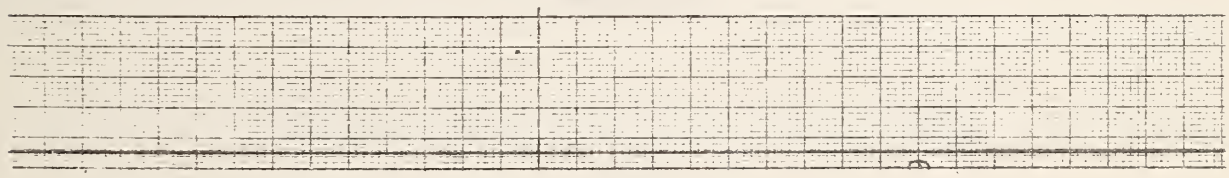

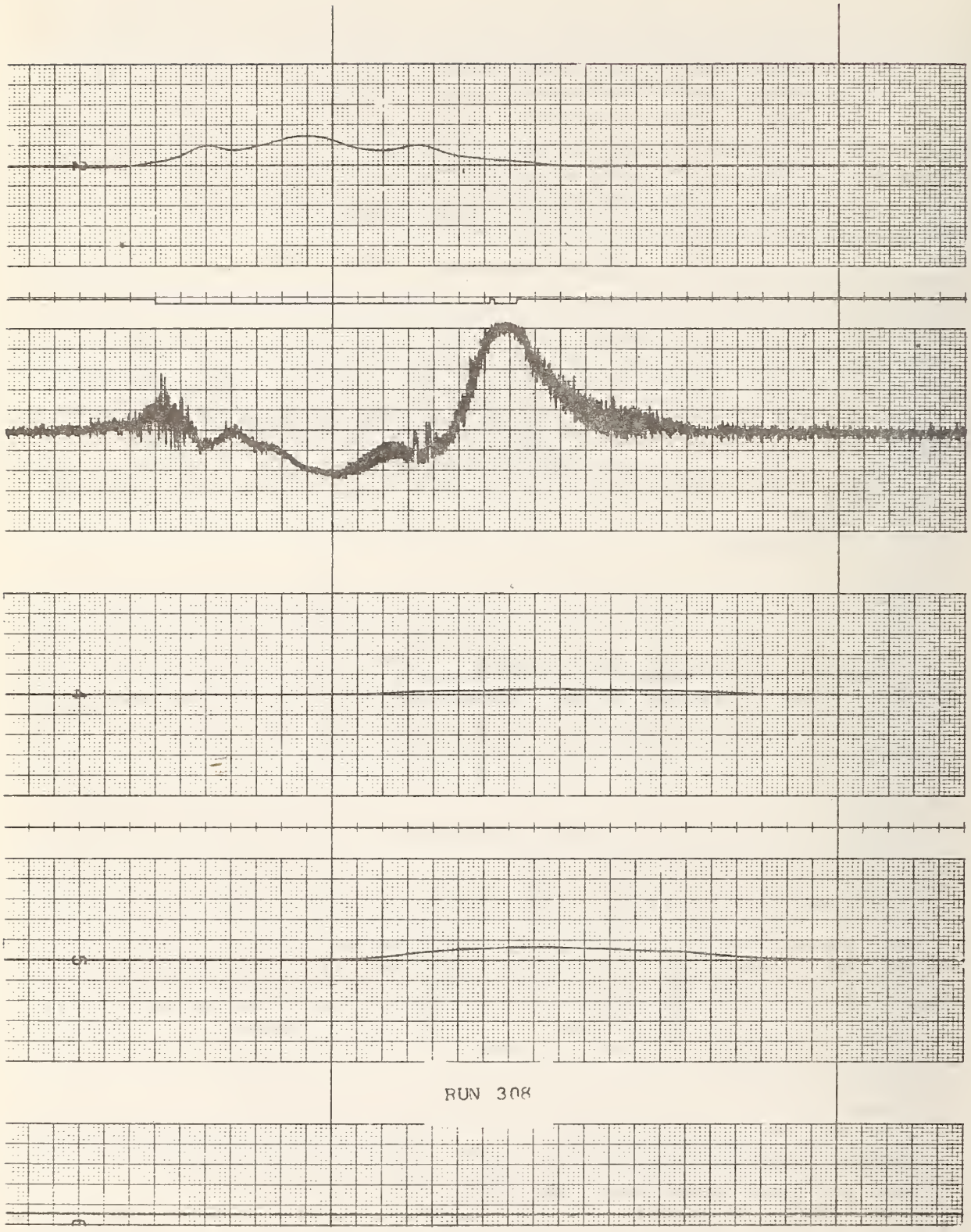

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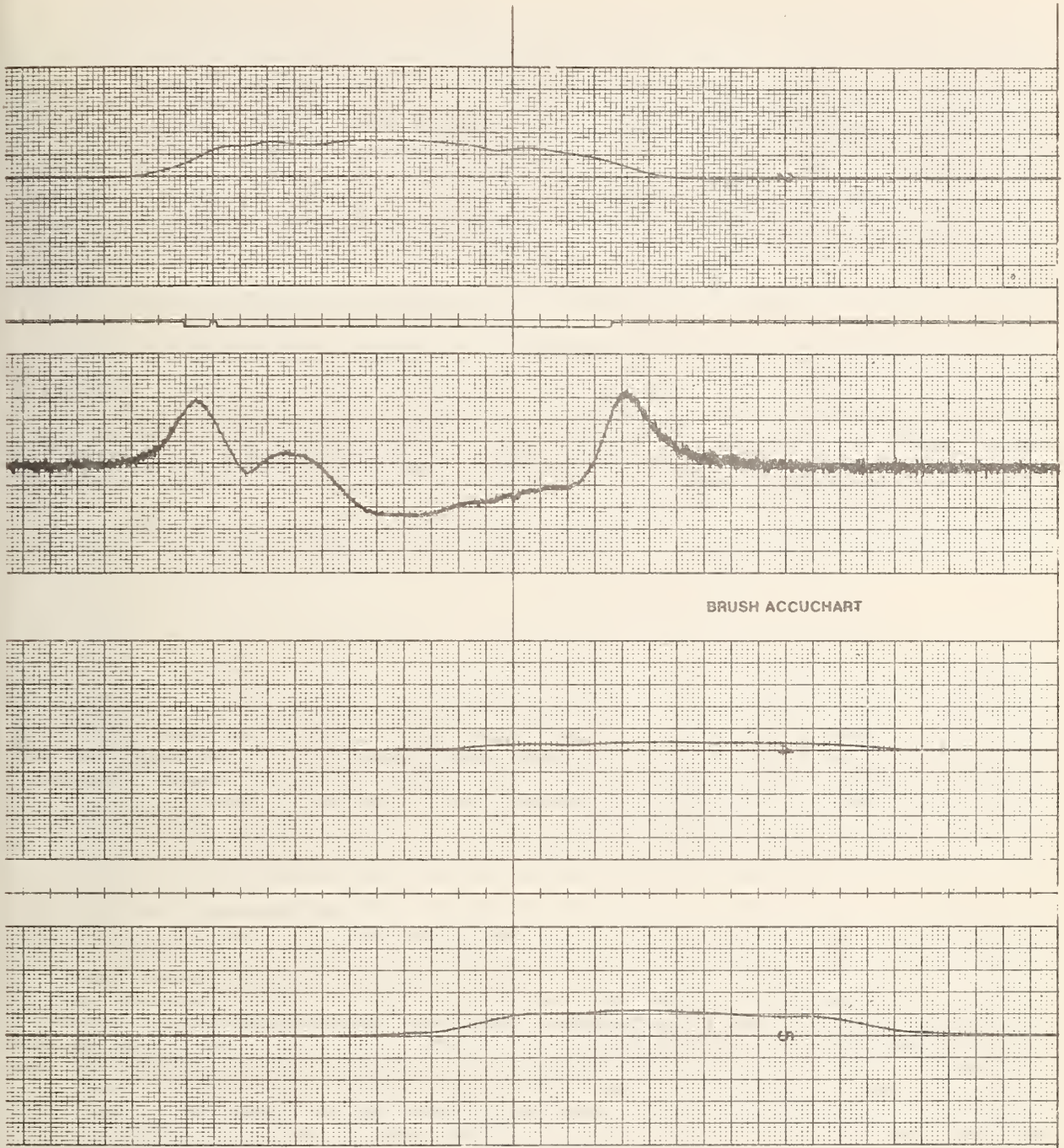

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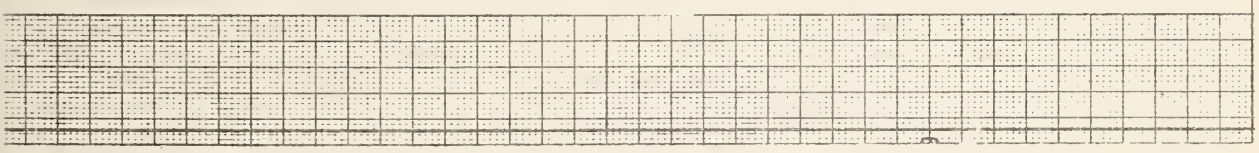

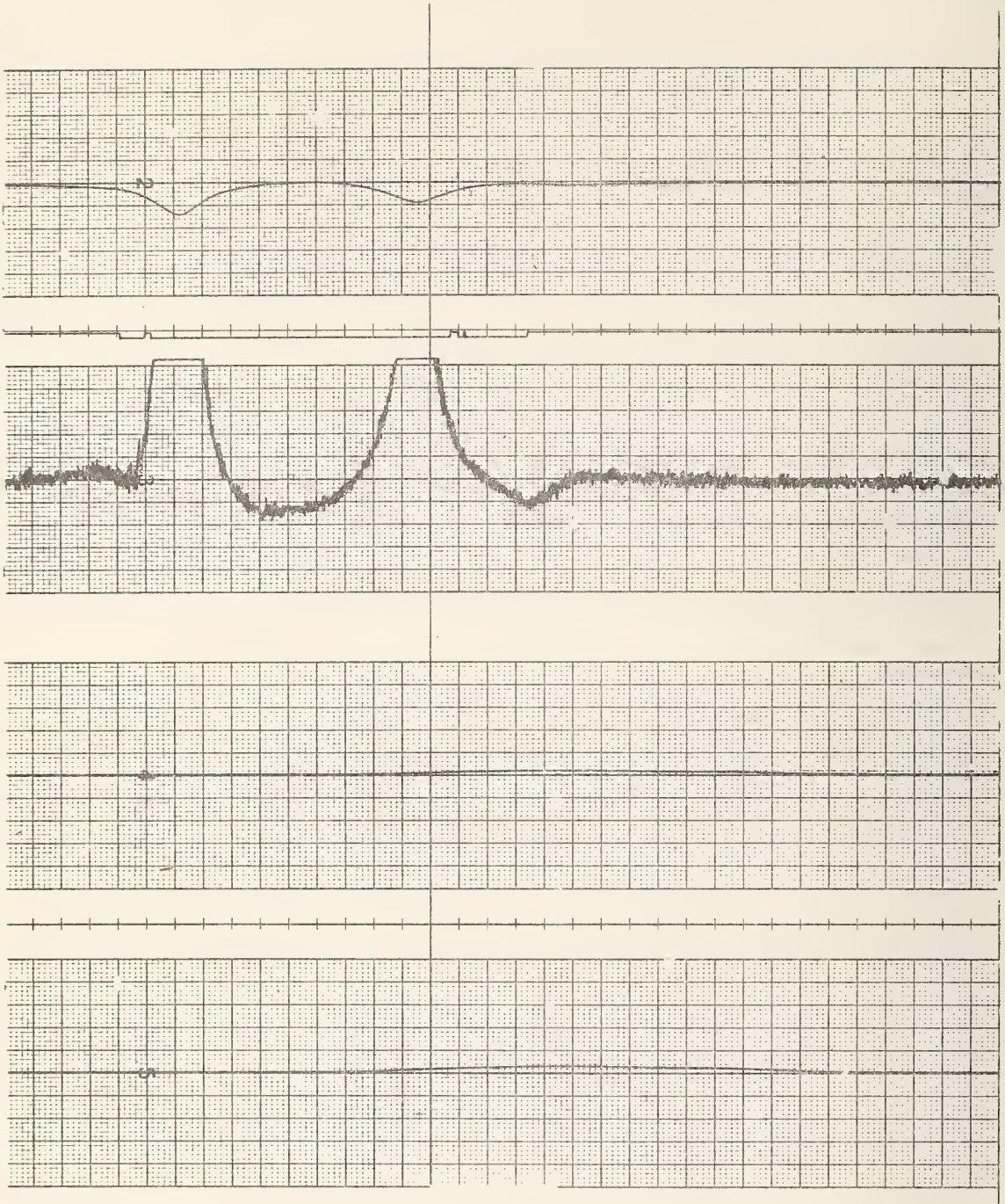

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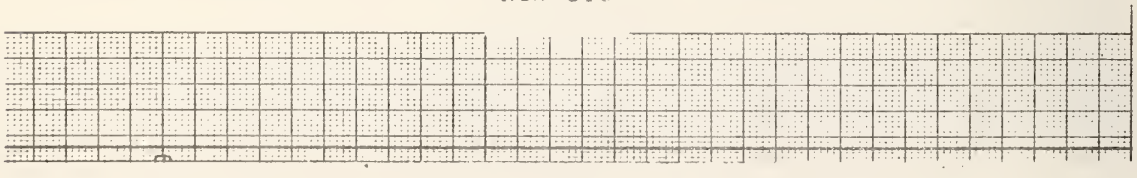

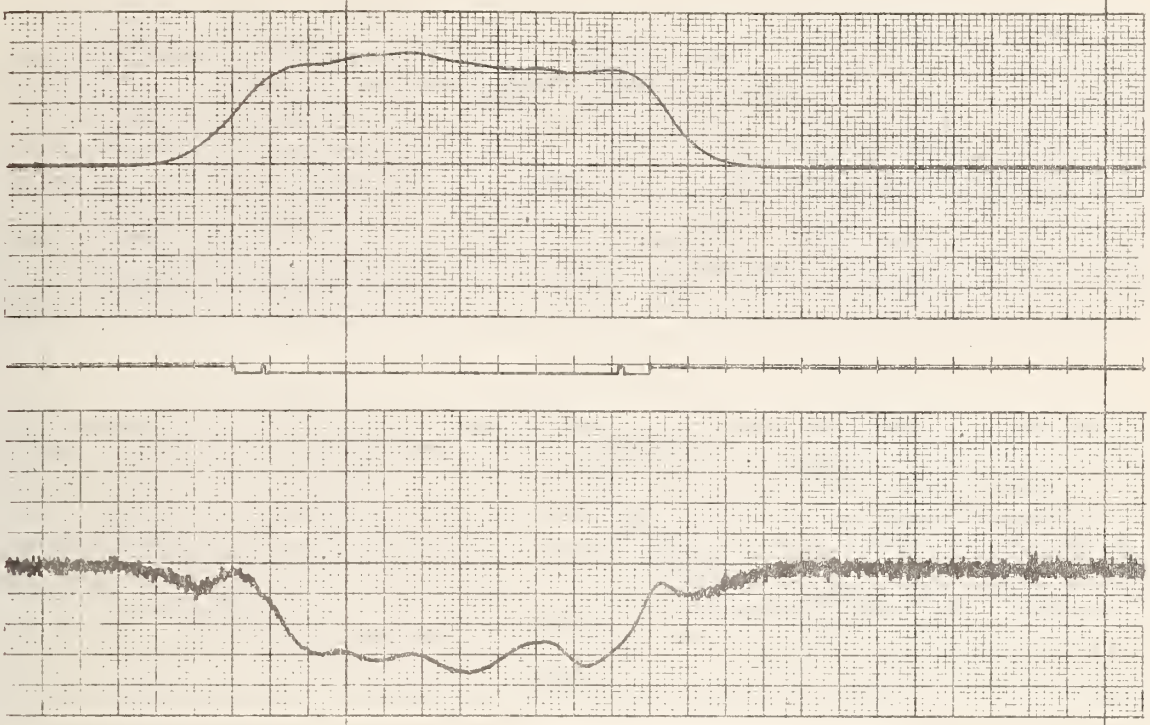

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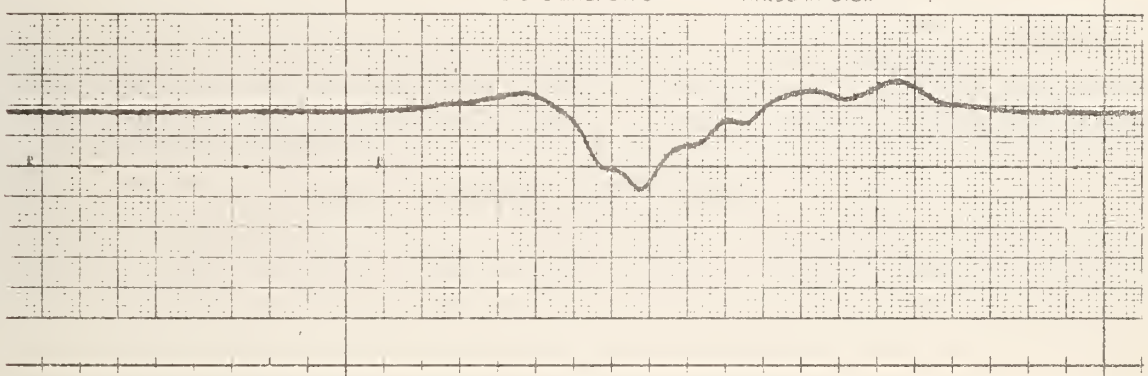

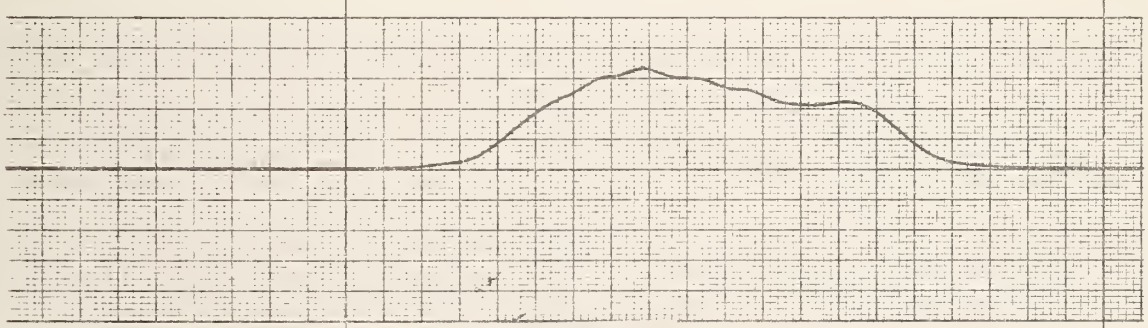

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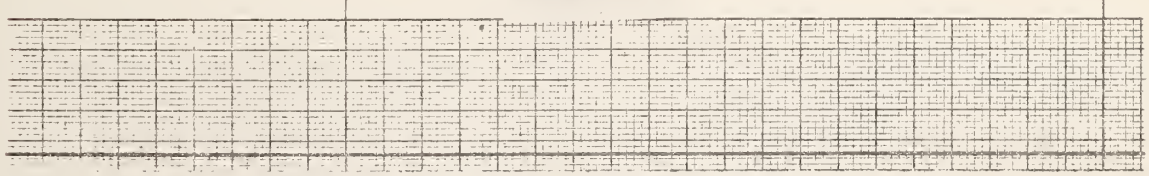

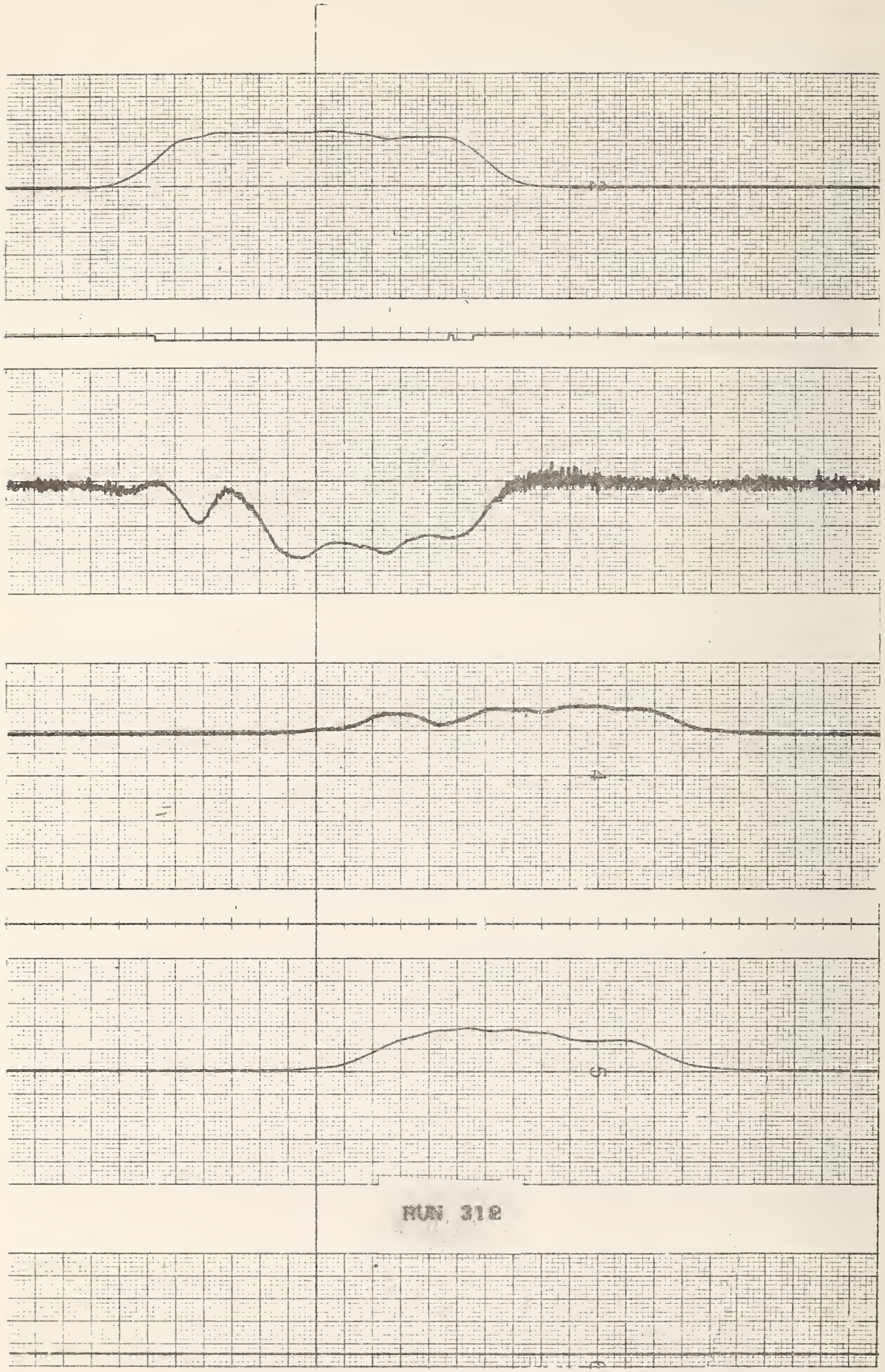
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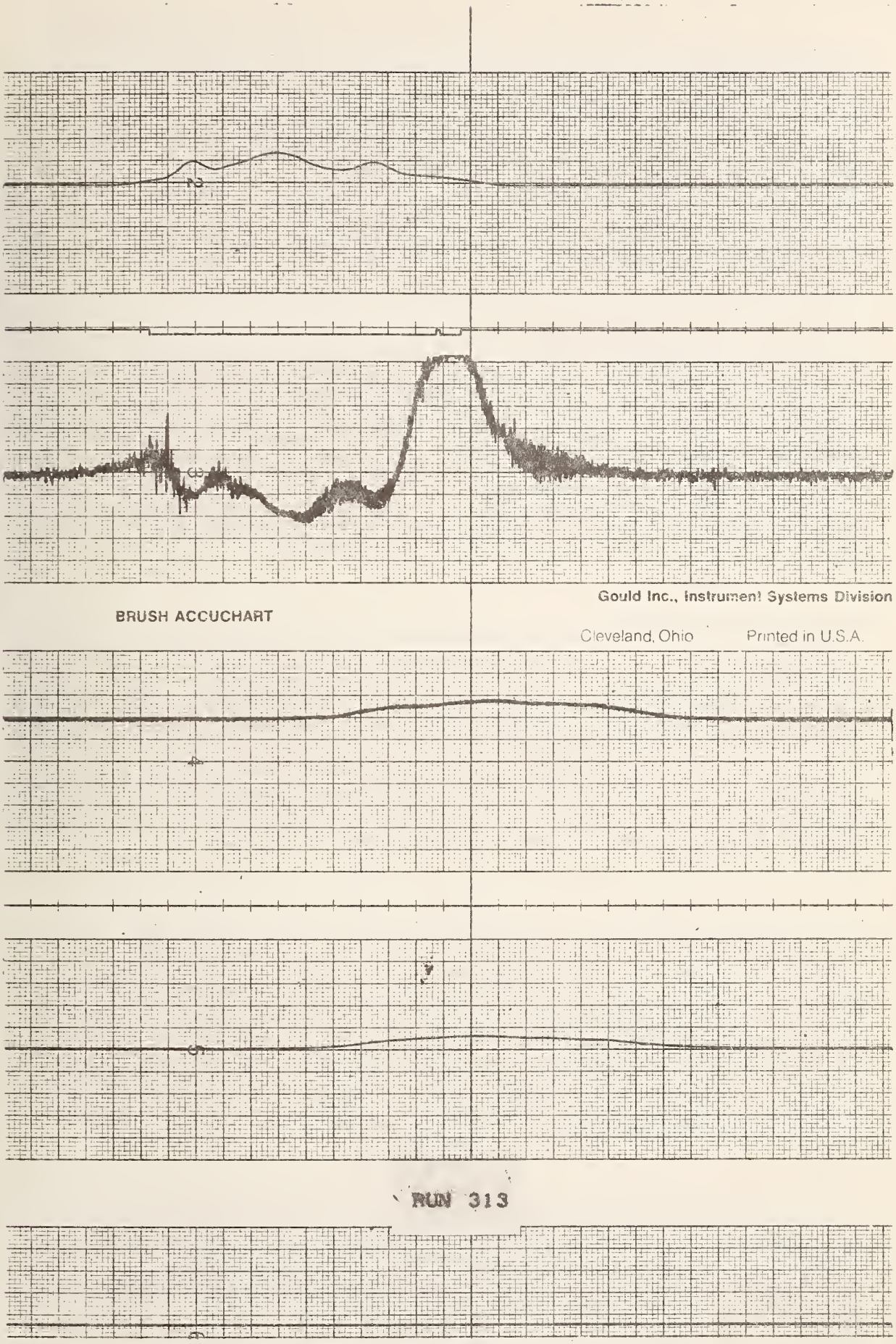
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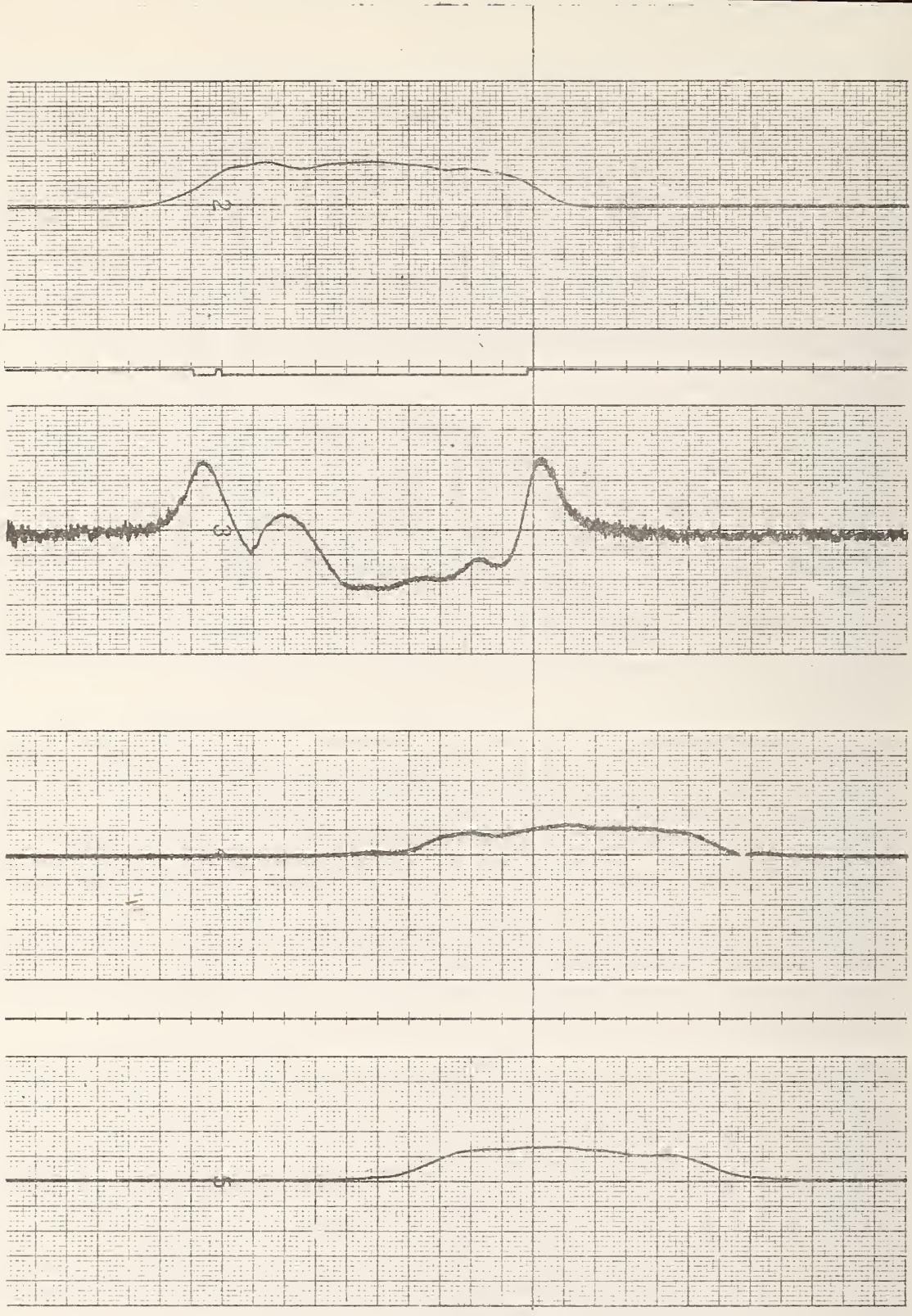
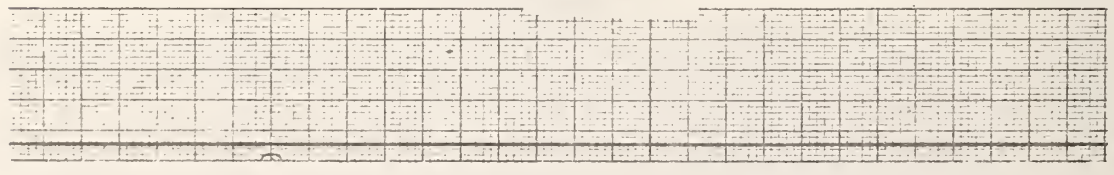
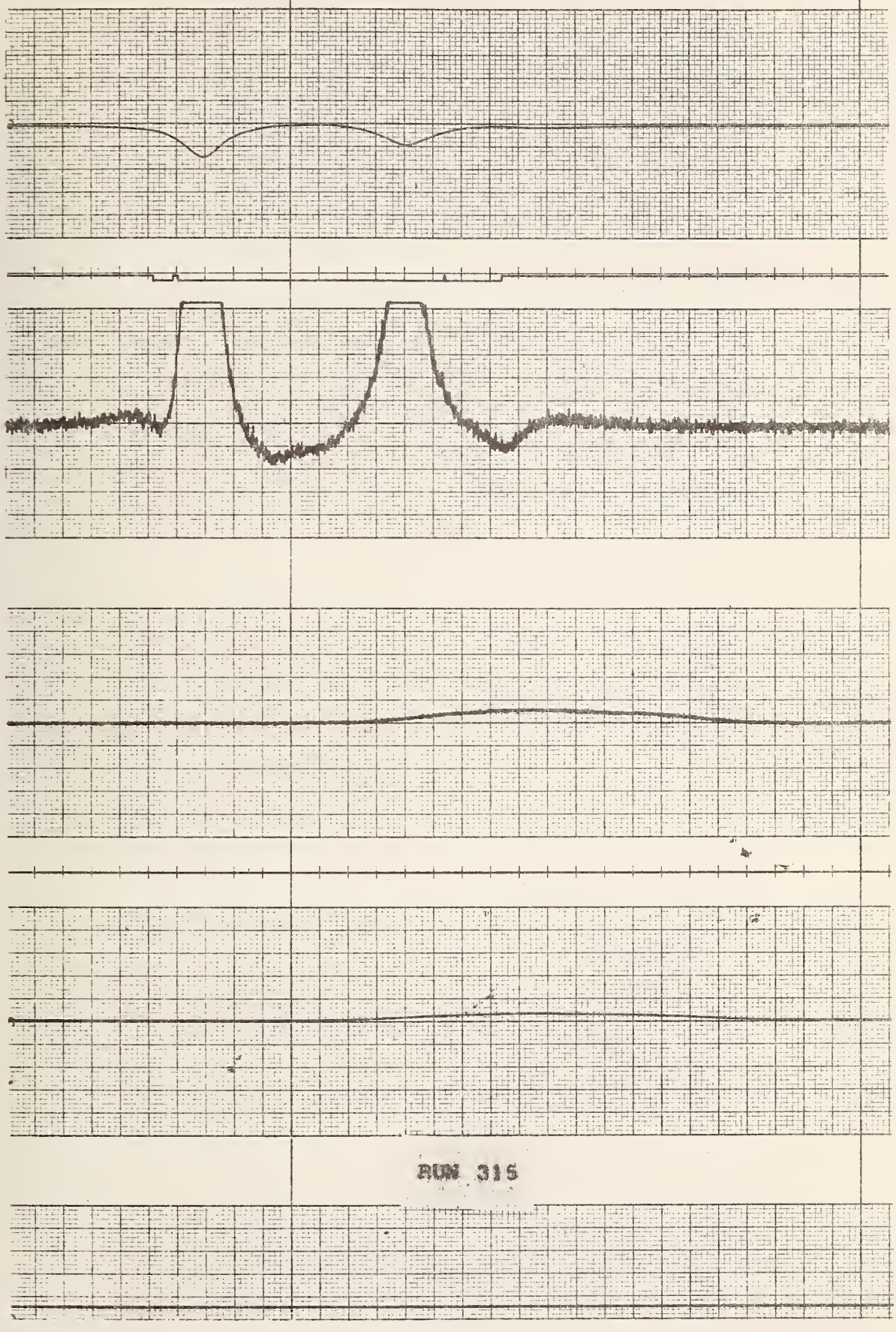


RUN 314

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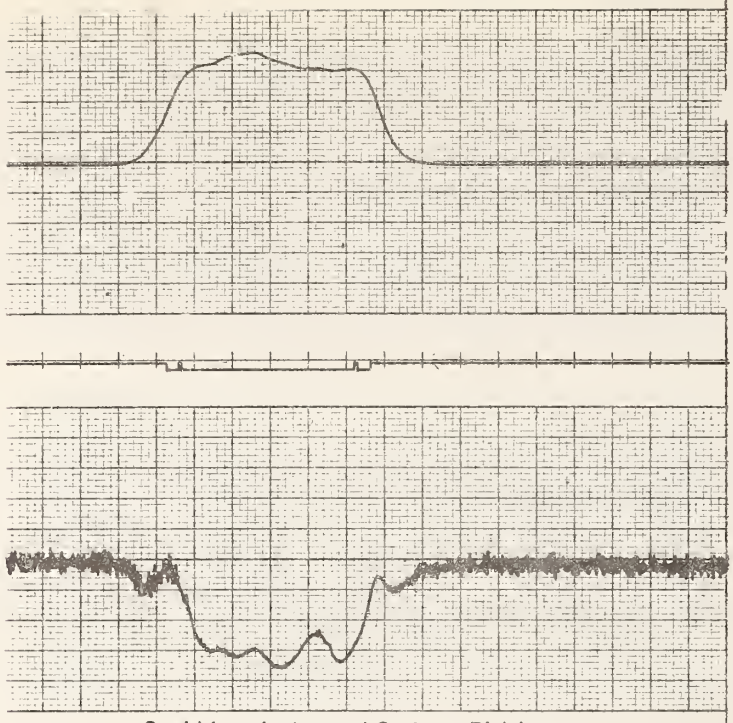

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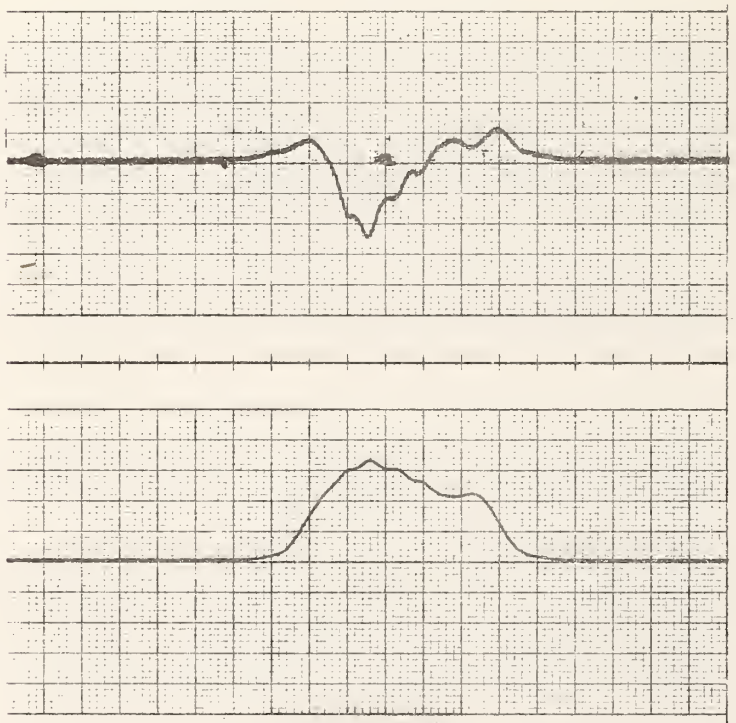

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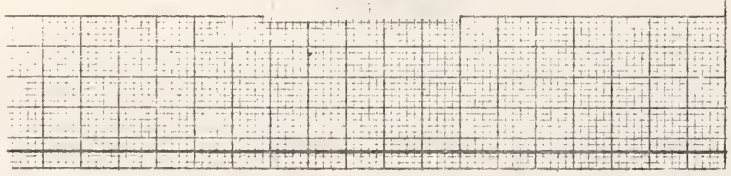

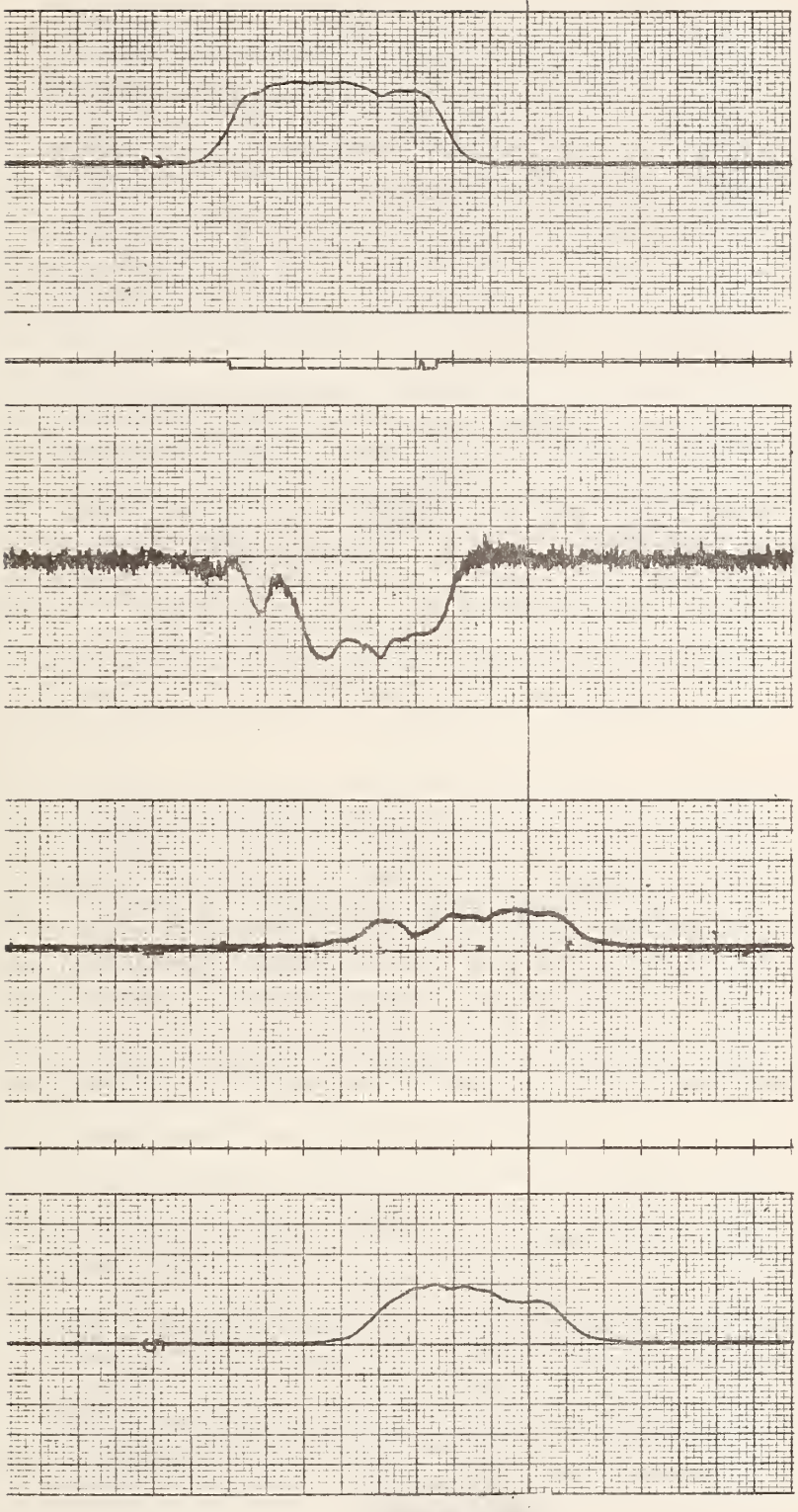

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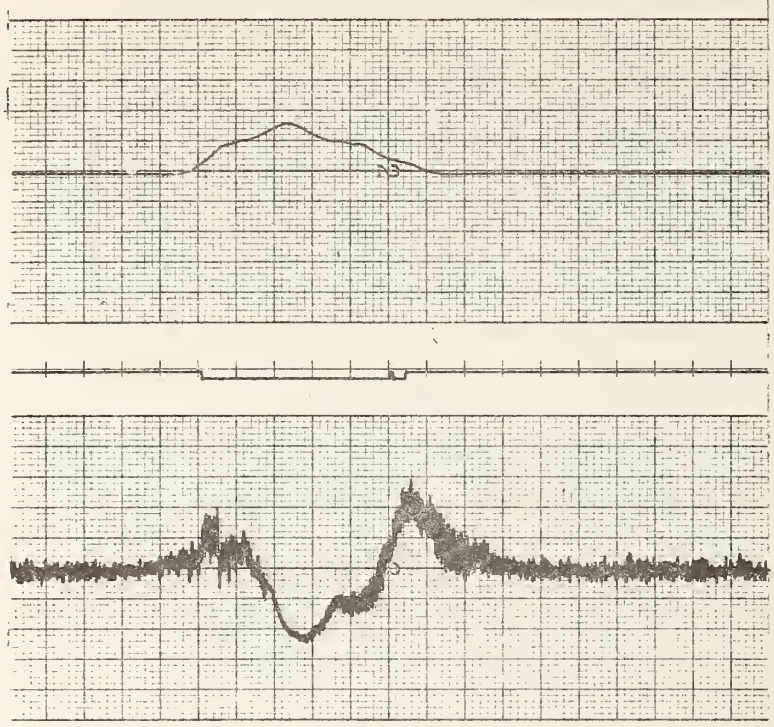

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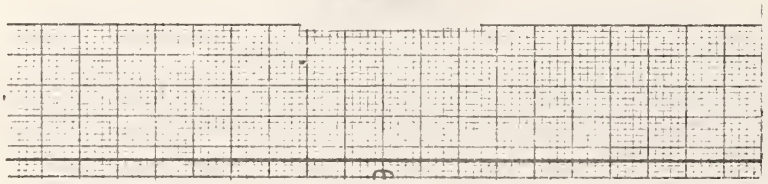

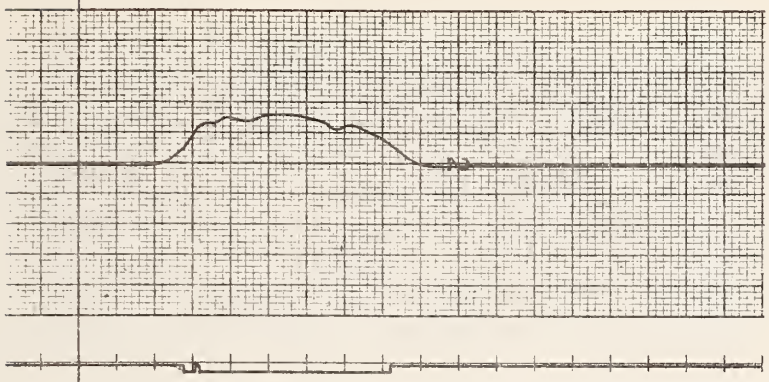

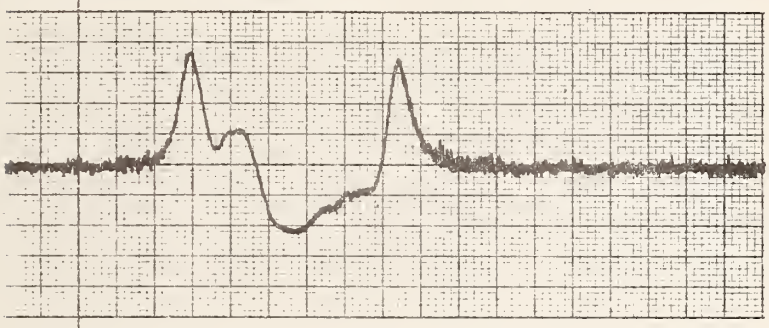

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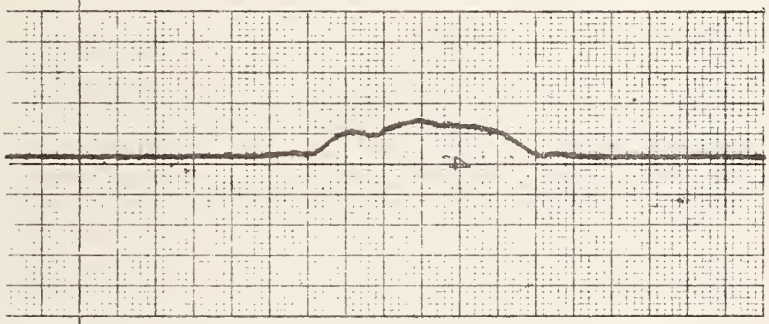

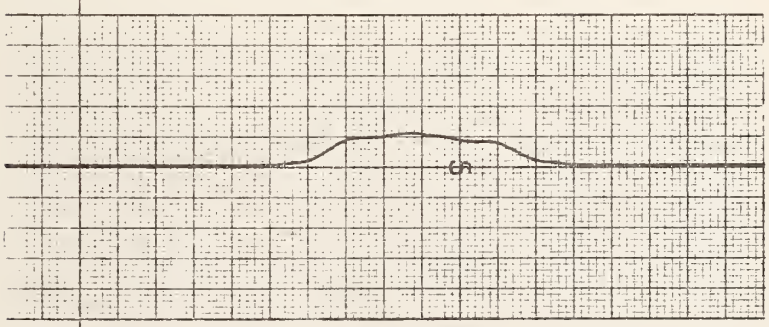

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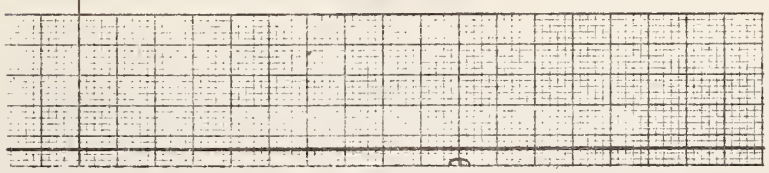

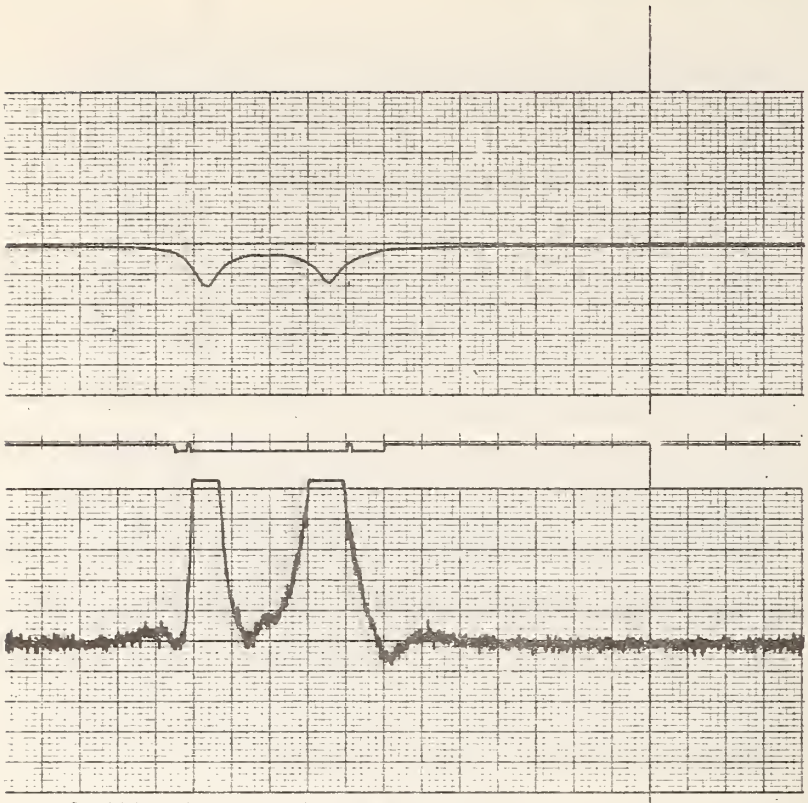

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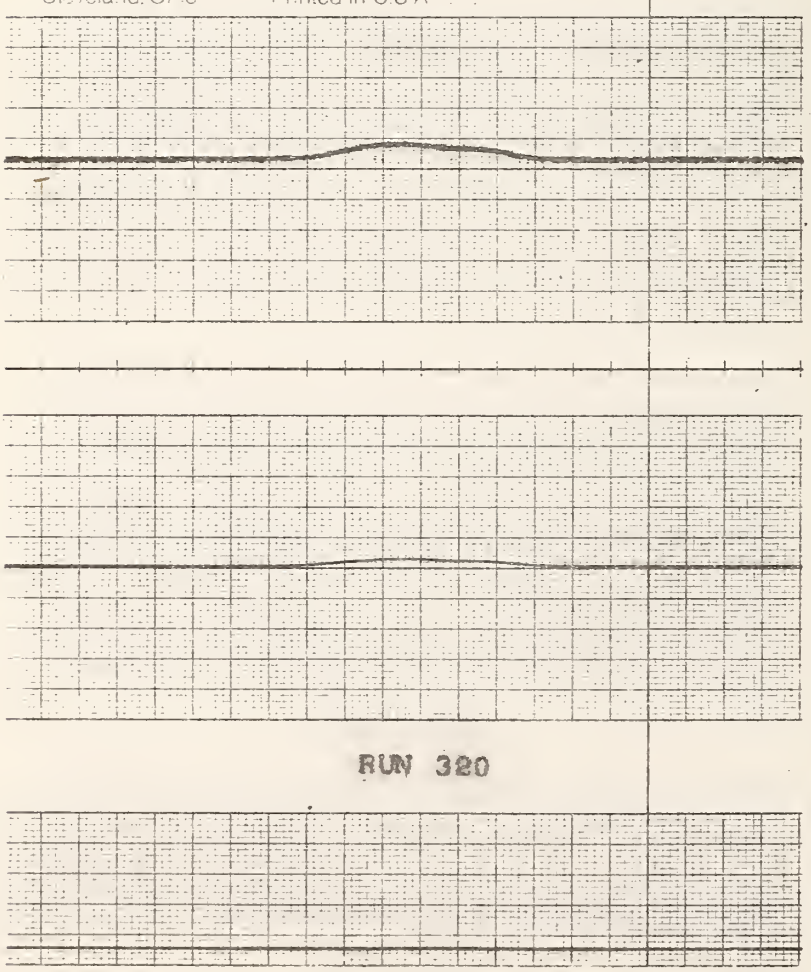

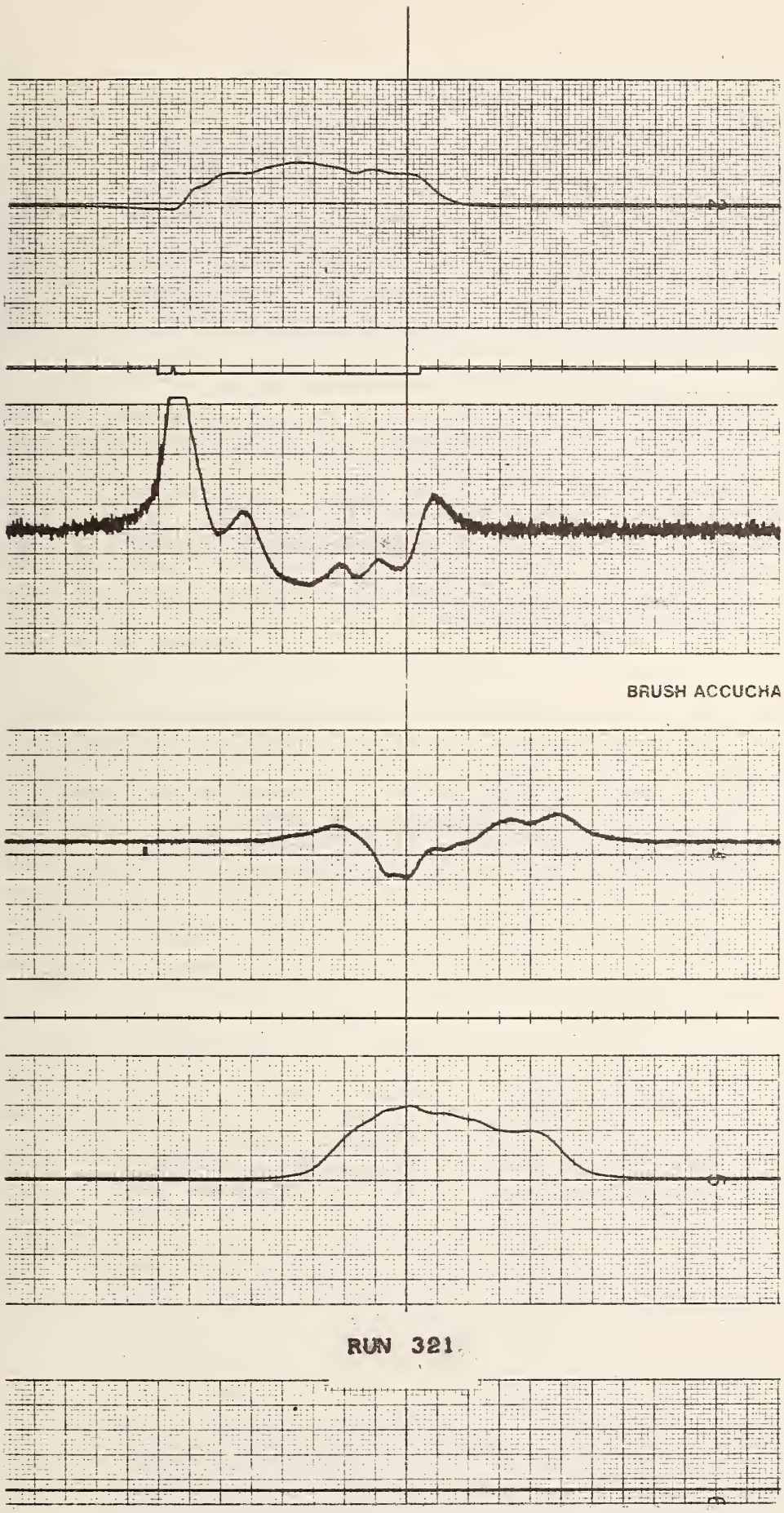

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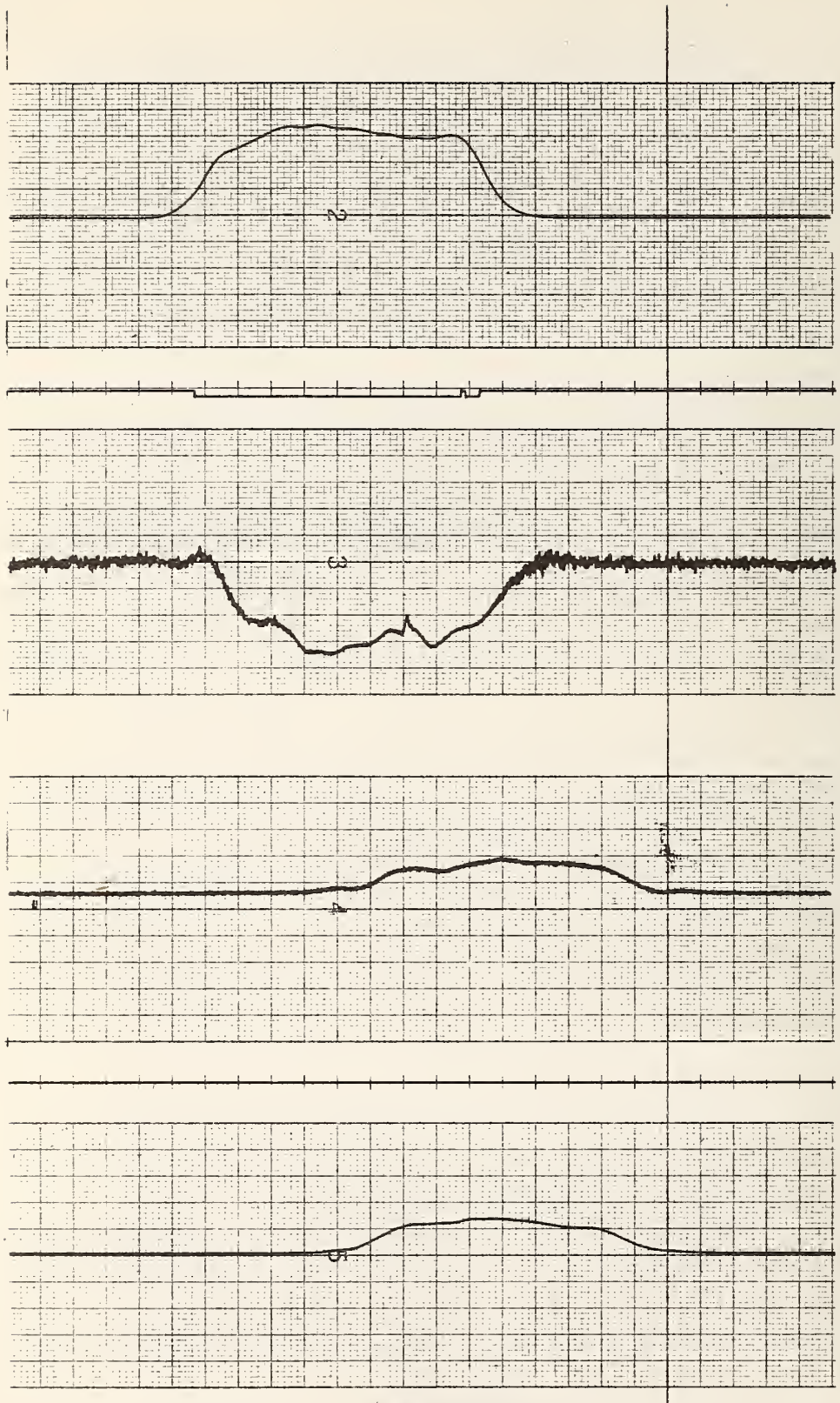
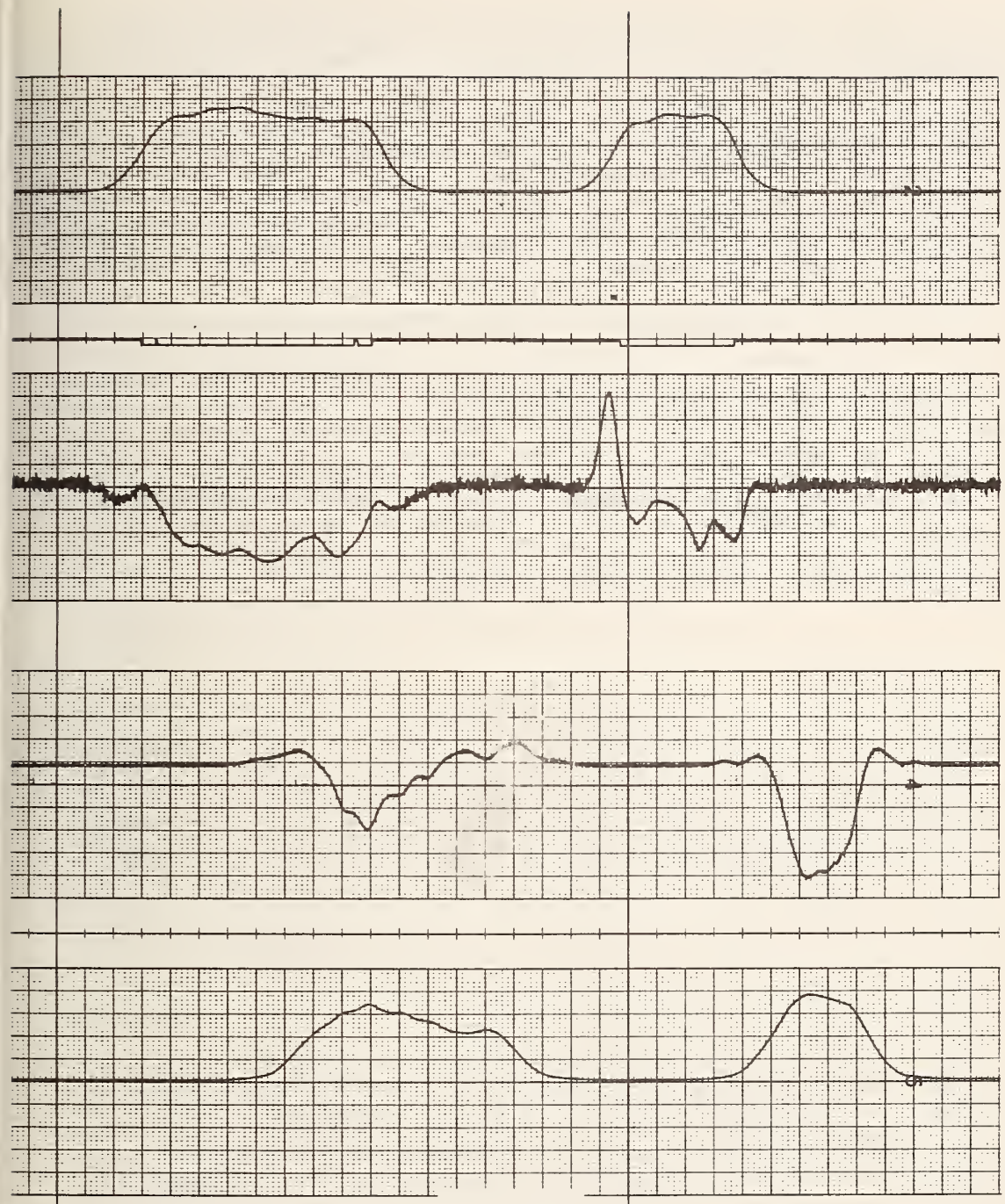


RUN 322



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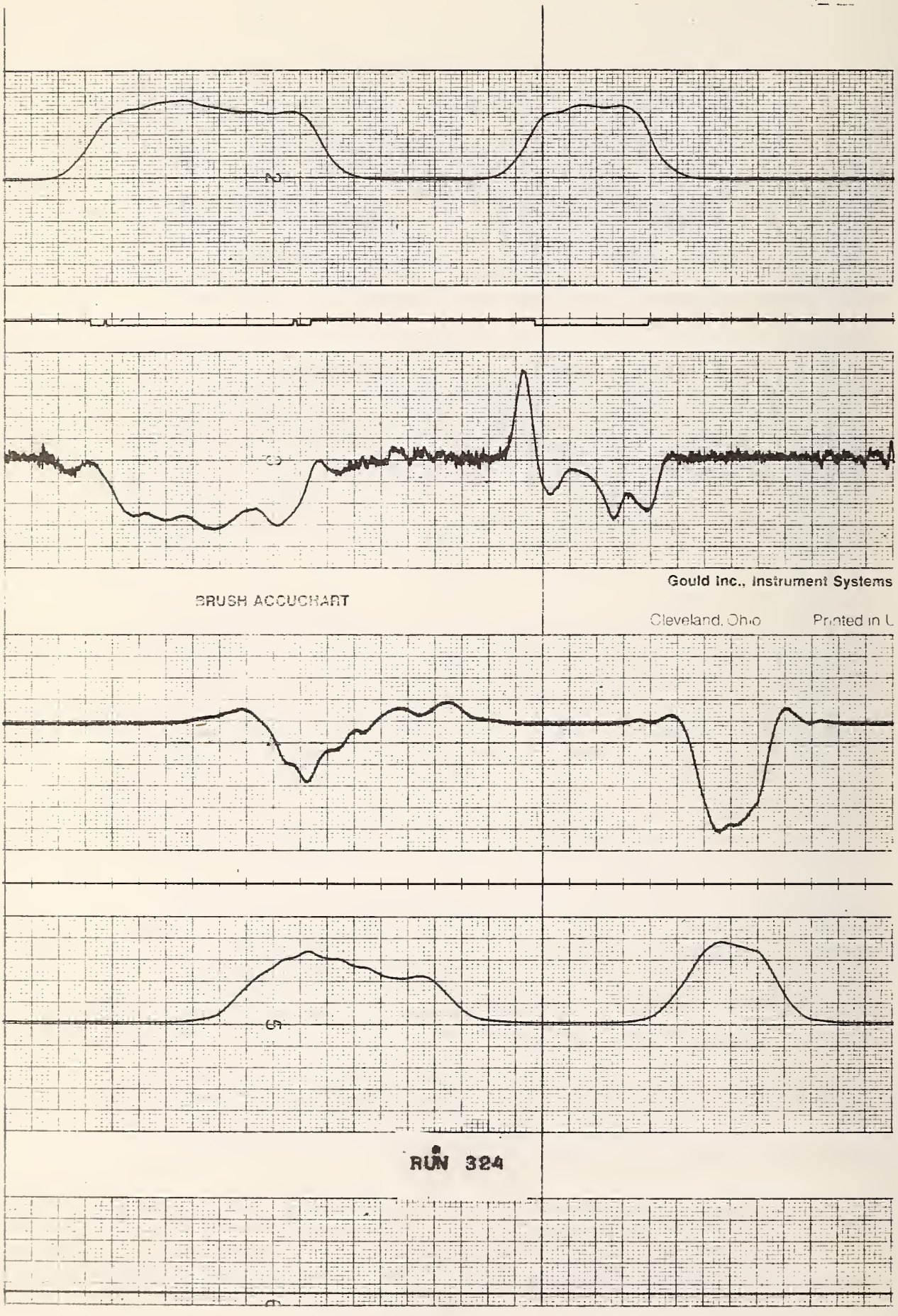
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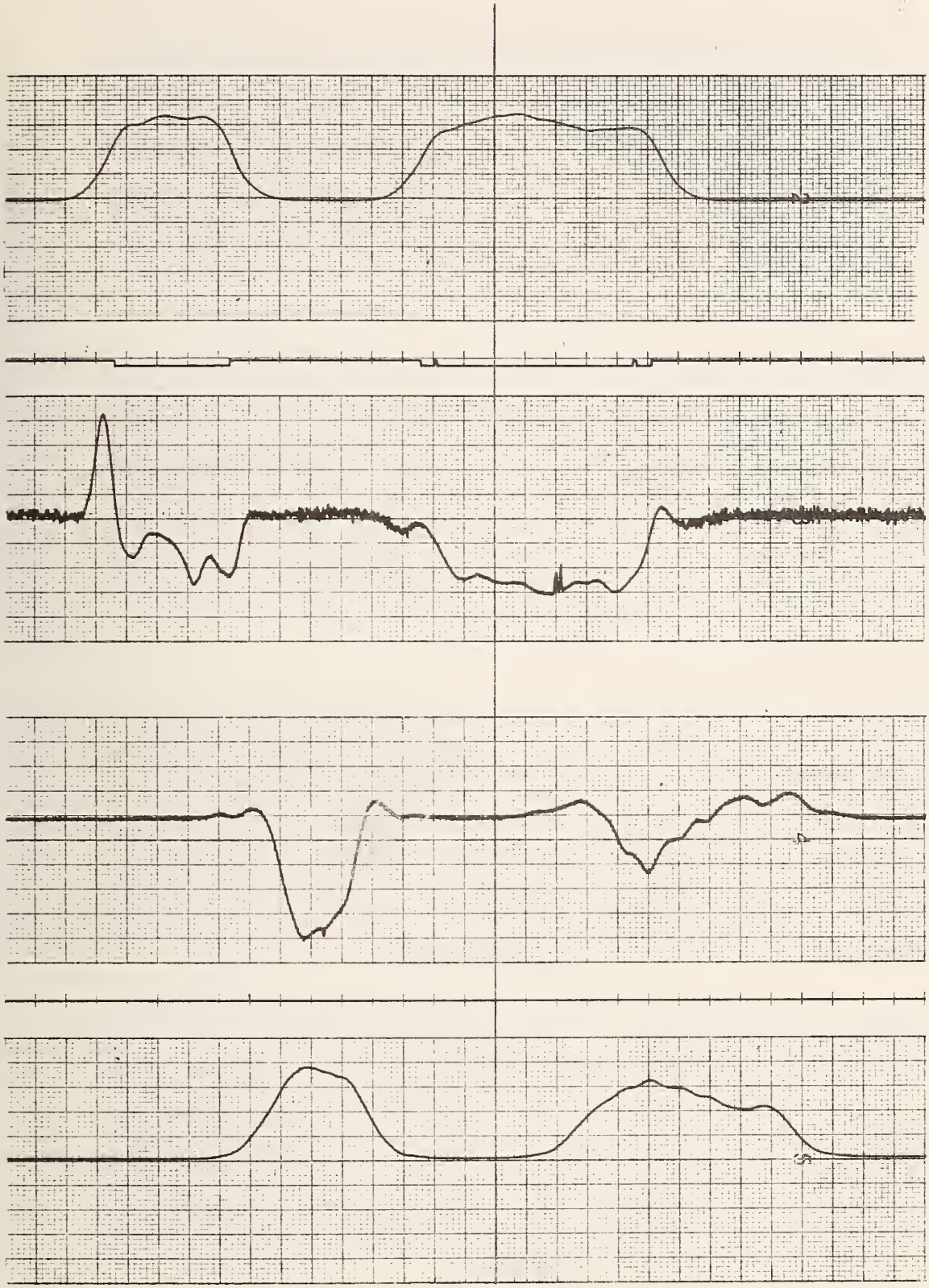
RUN 324



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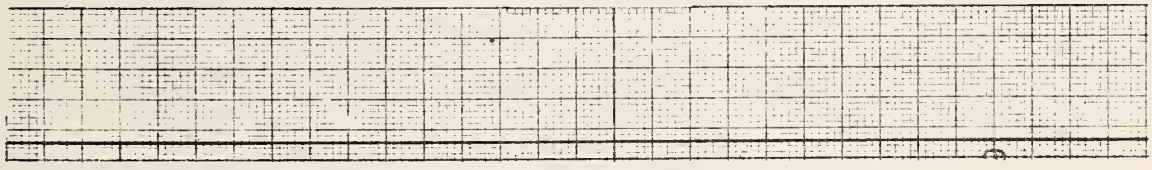
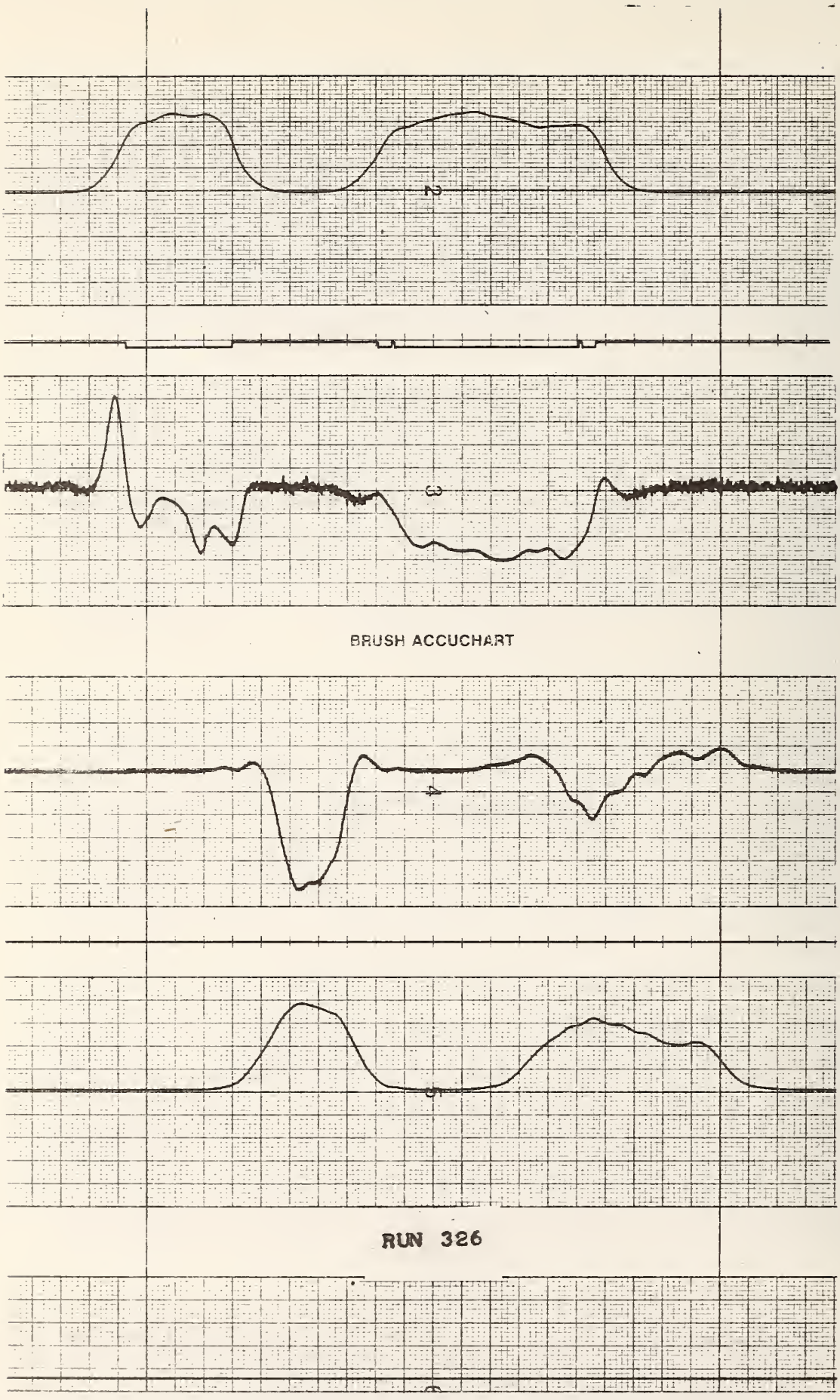
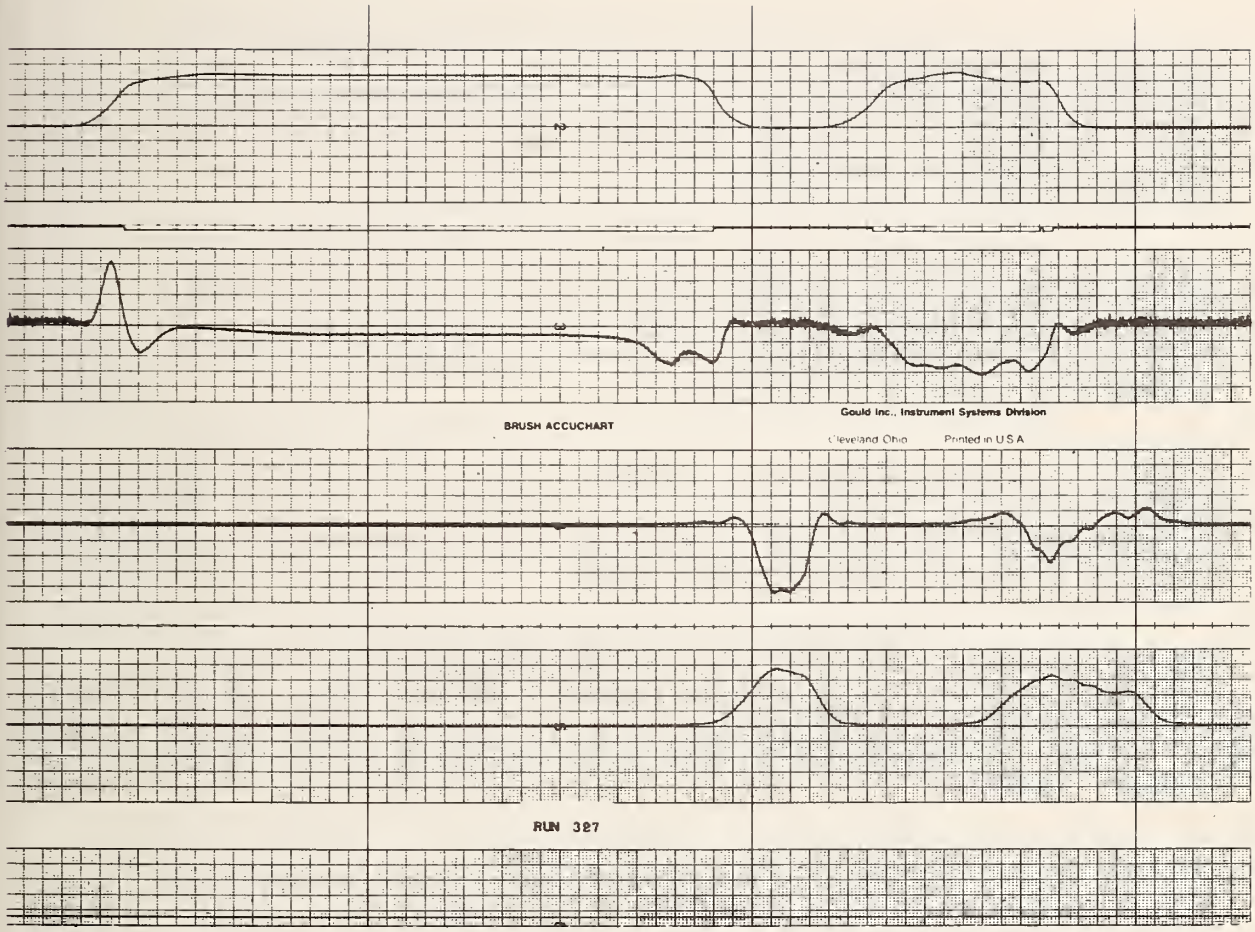




RUN 326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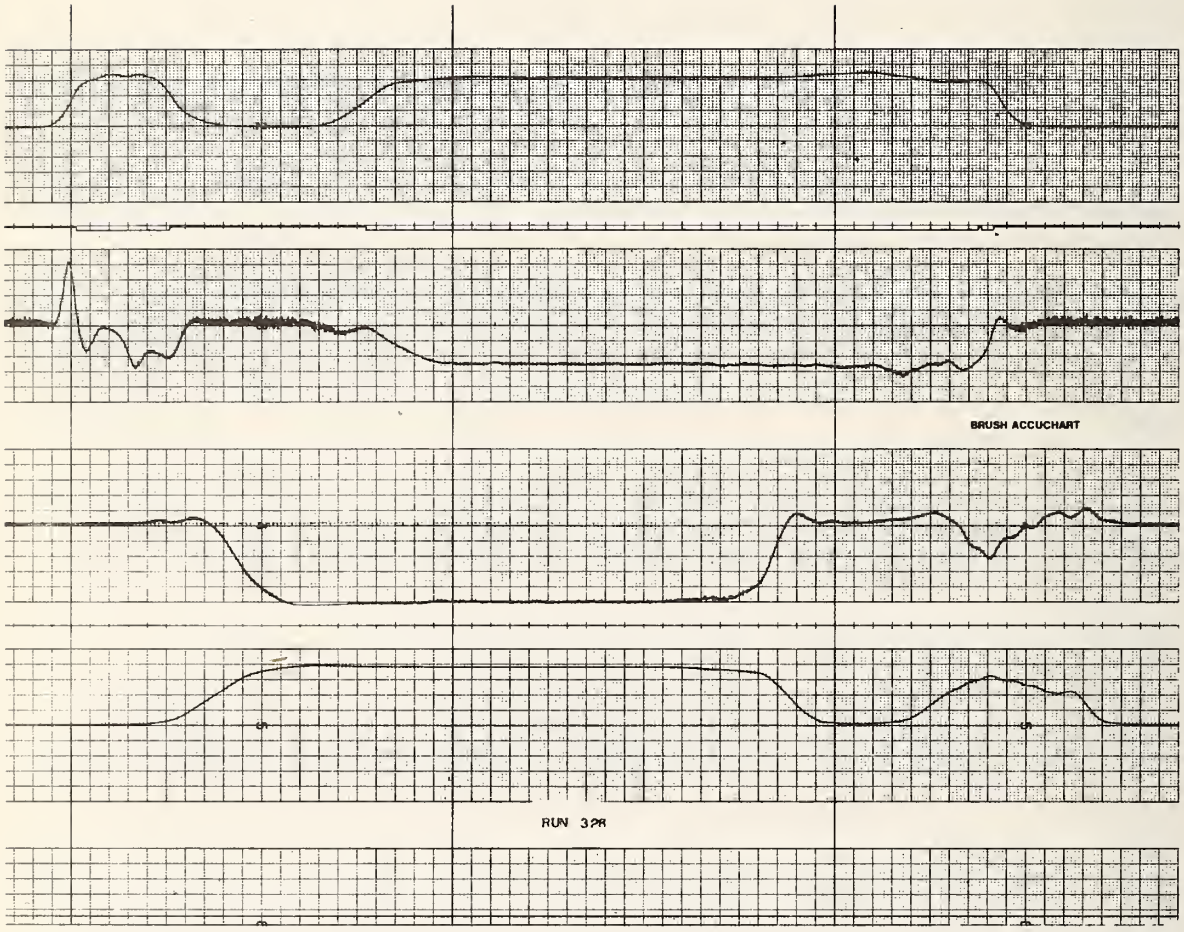
RUN 327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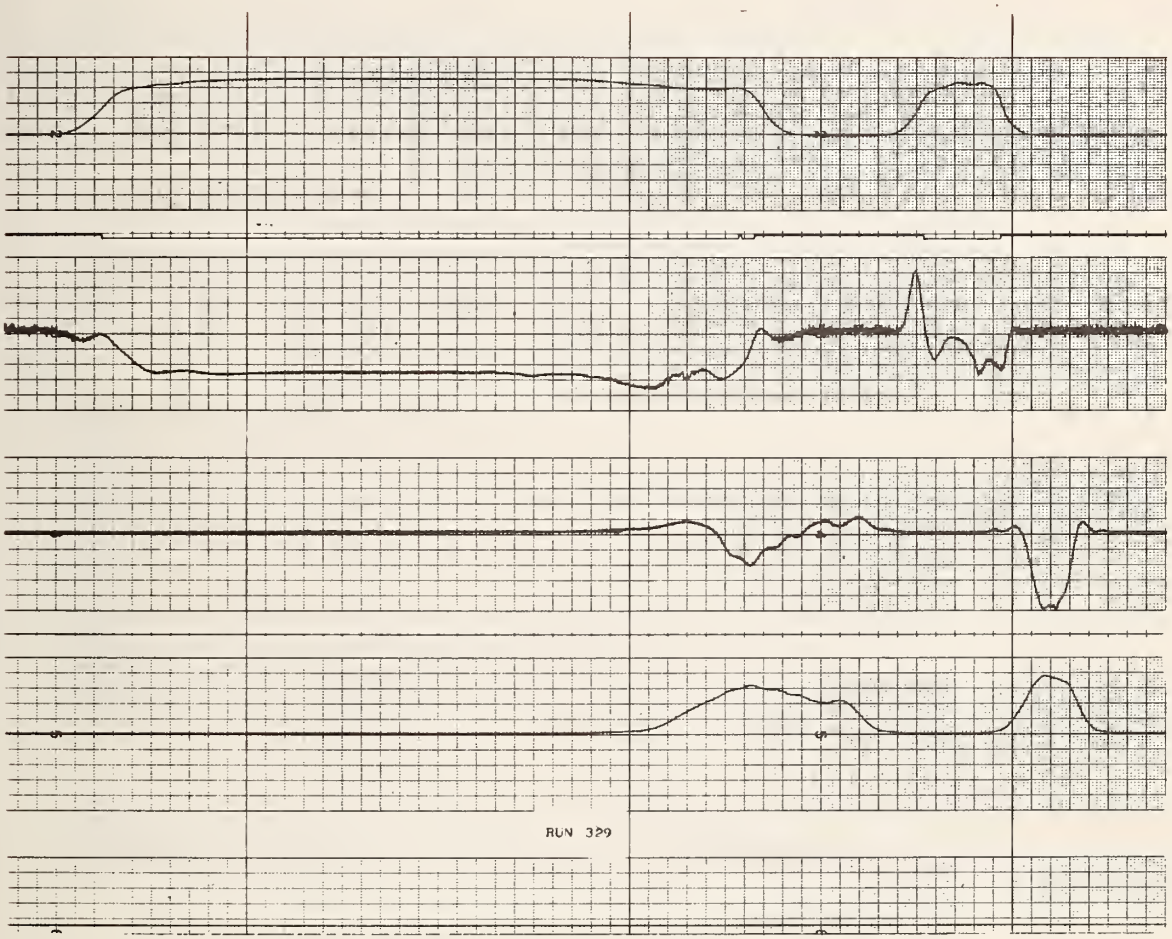
RUN 328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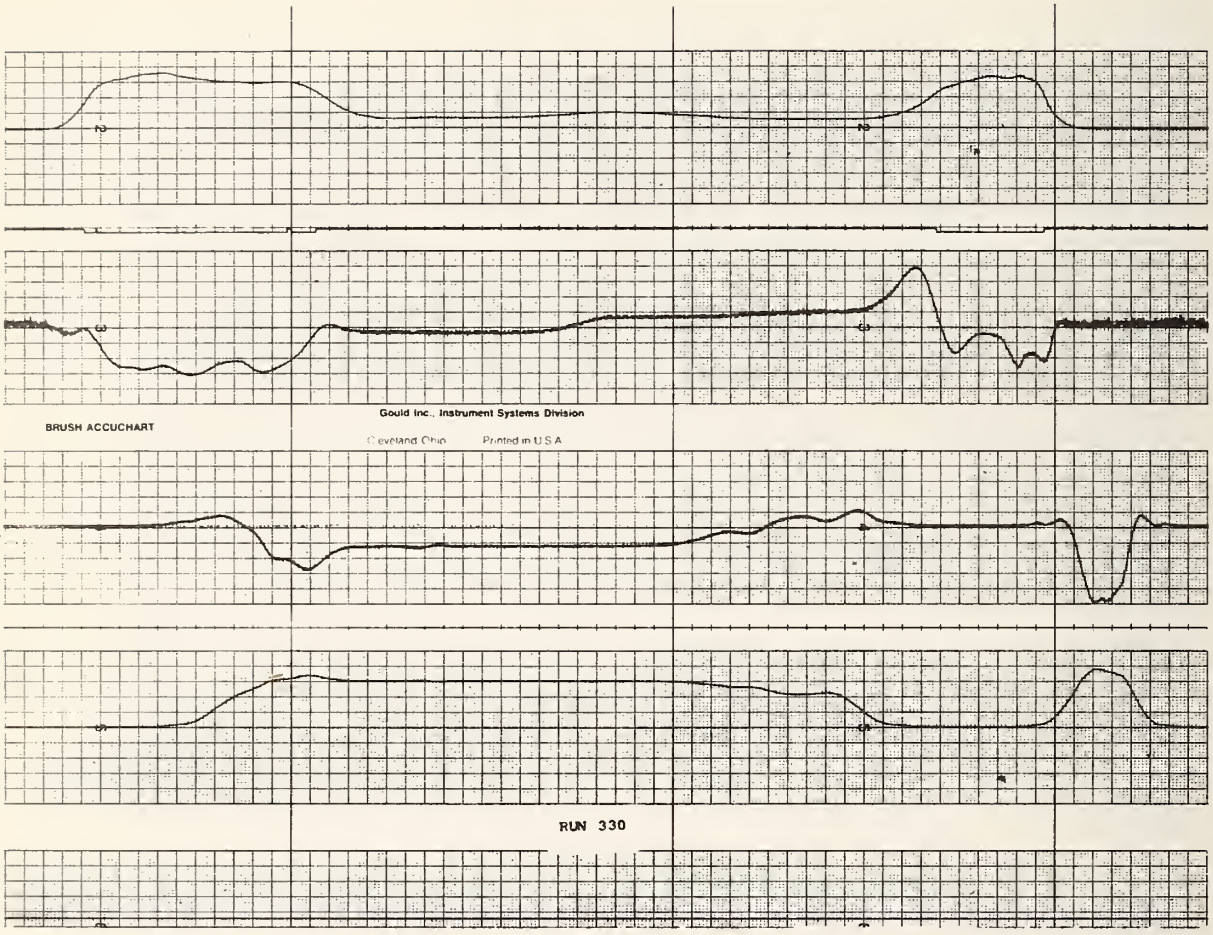
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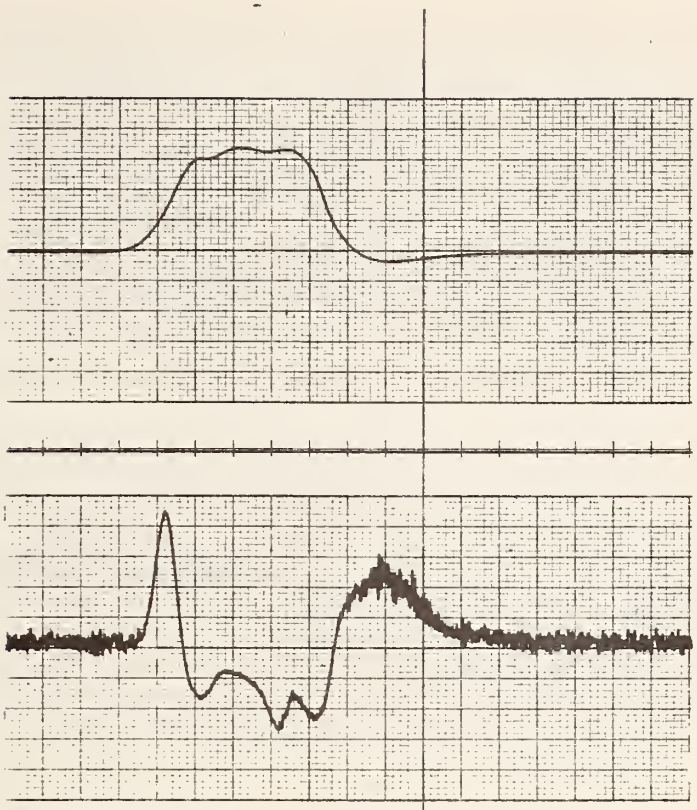
RUN 330



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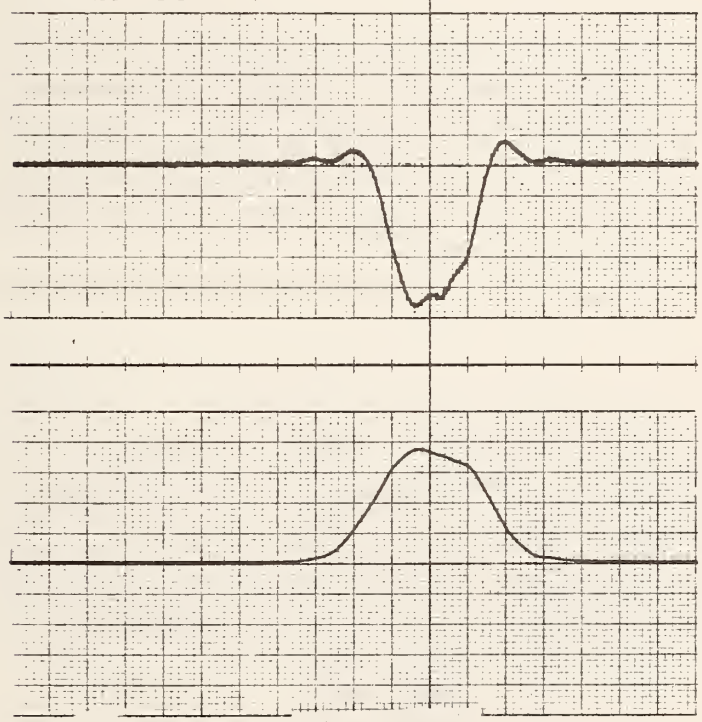

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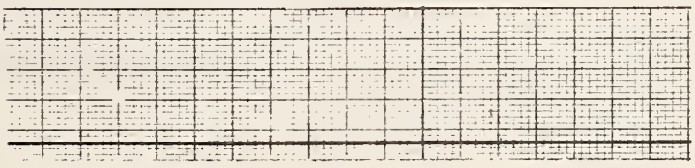
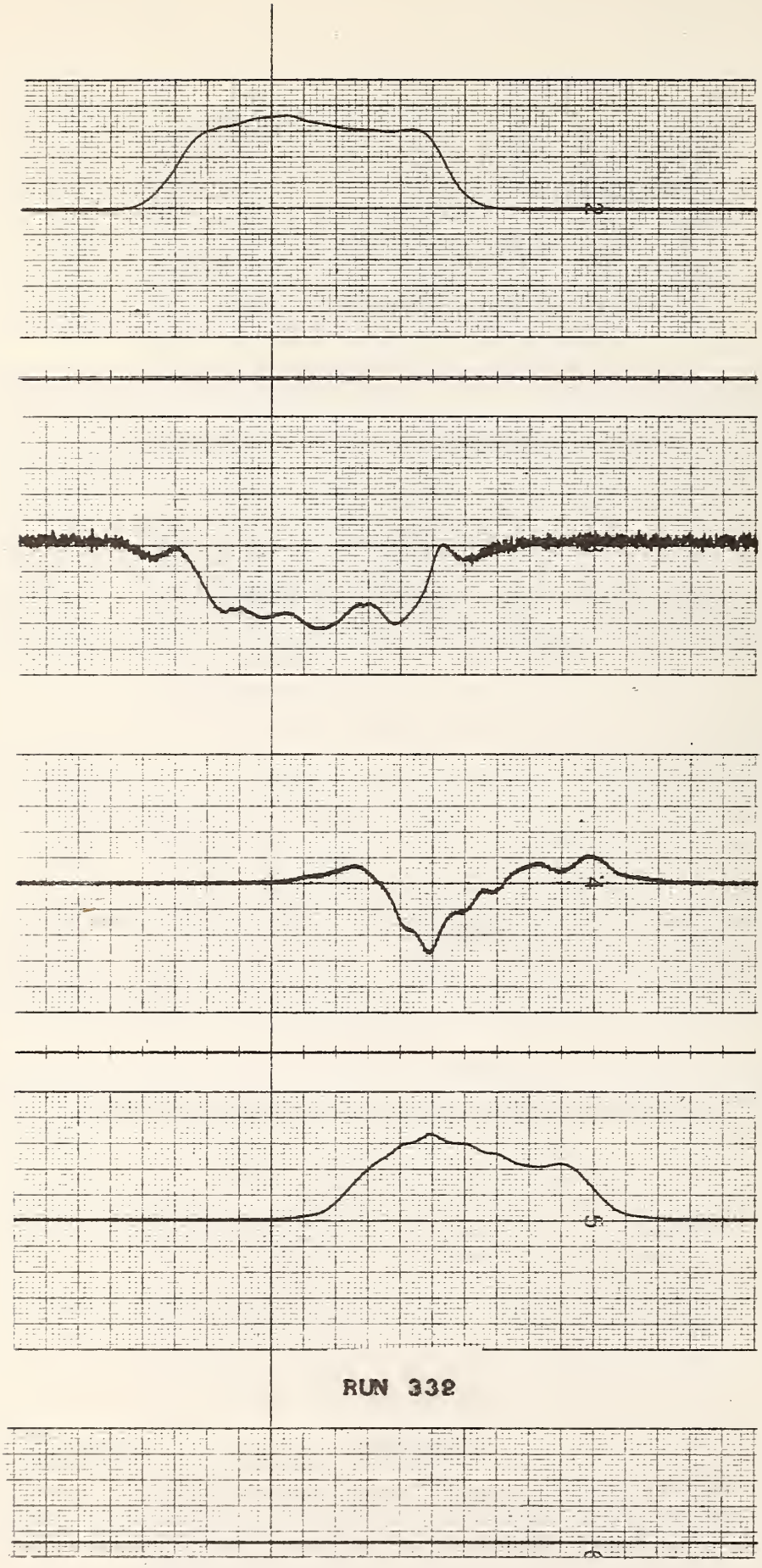




RUN 332

Run 333

No Strip Recording
Available

Runs 334-365

From top to bottom:

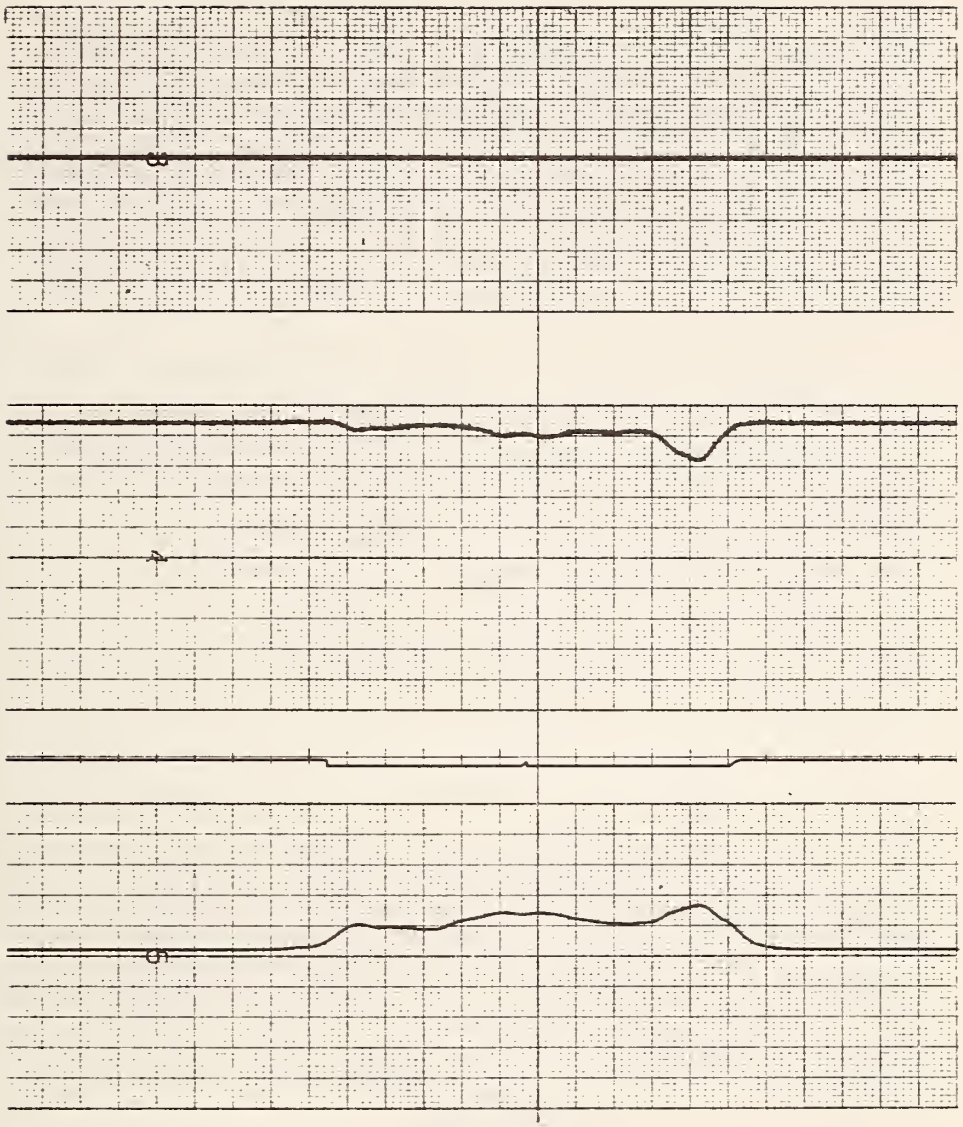
Trace 1 = N/A

Trace 2 = ILD amplitude

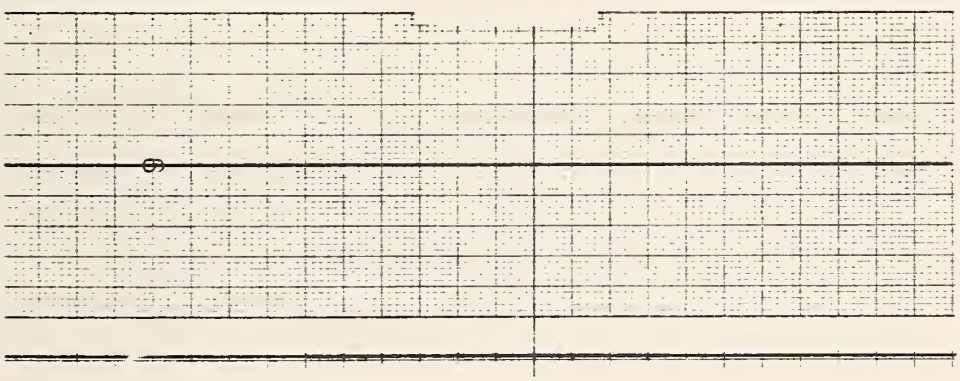
Trace 3 (Marker) = Optical presence detector

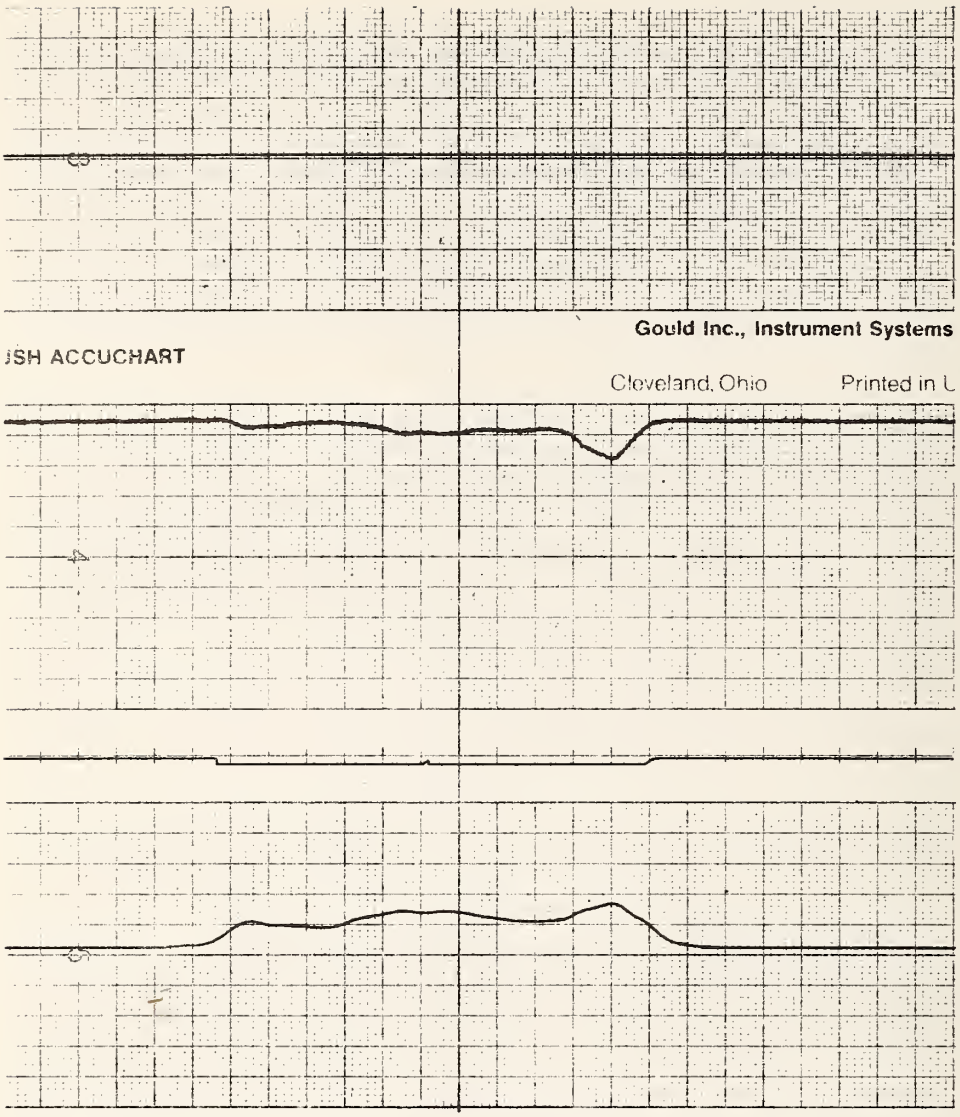
Trace 4 = ILD phase

Trace 5 = N/A



RUN 334

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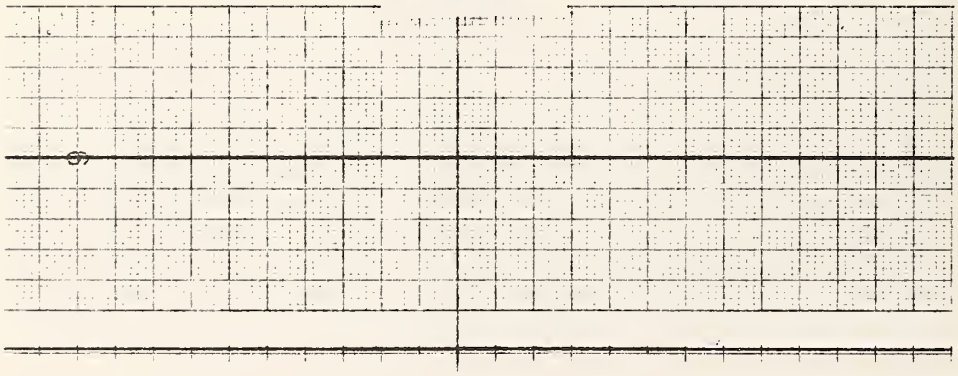
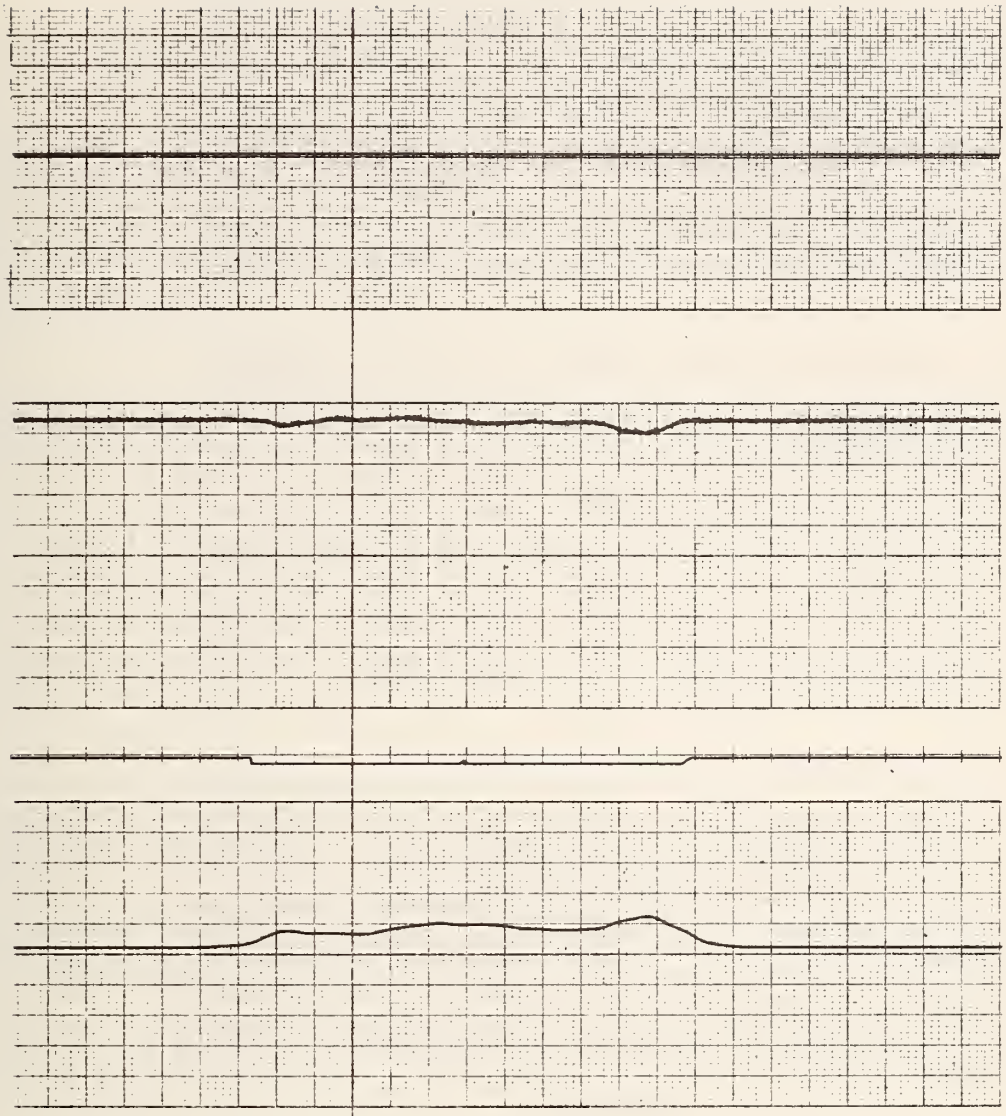
RUN 335





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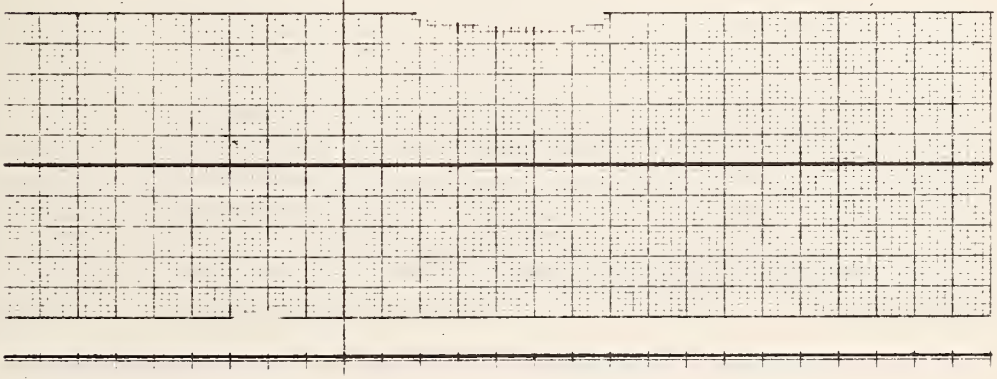
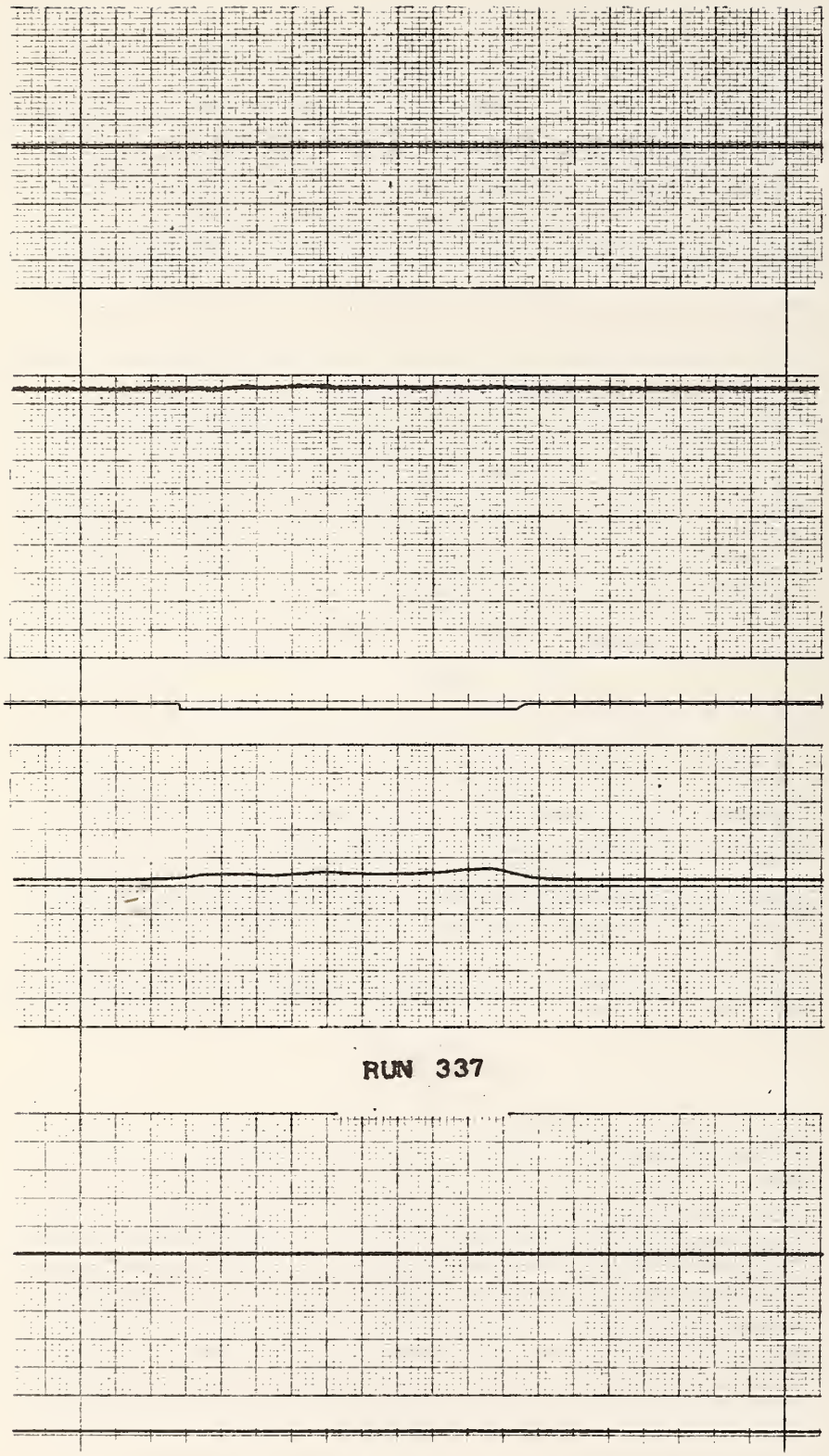
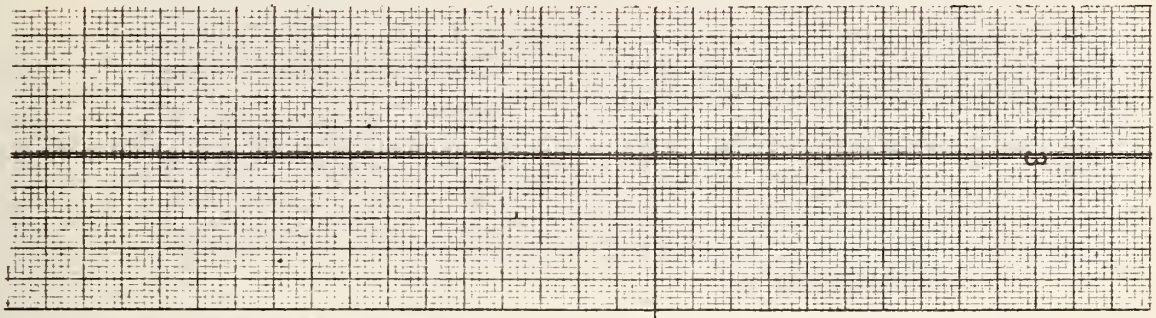



RUN 337



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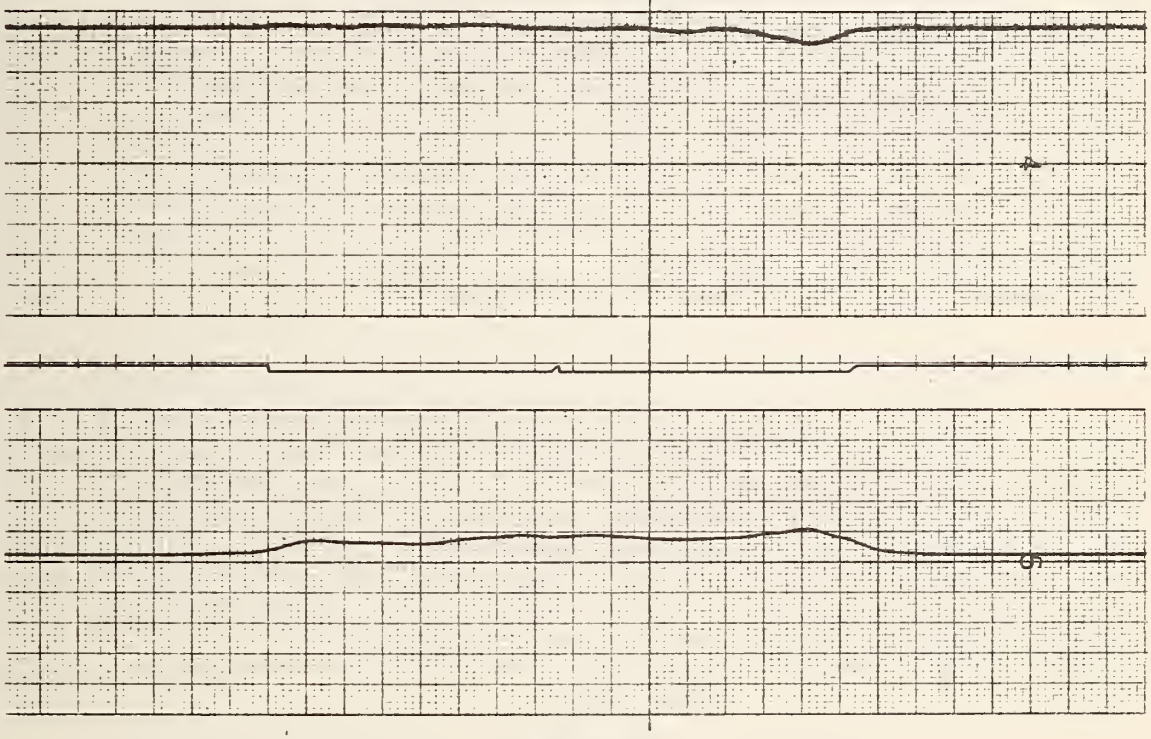

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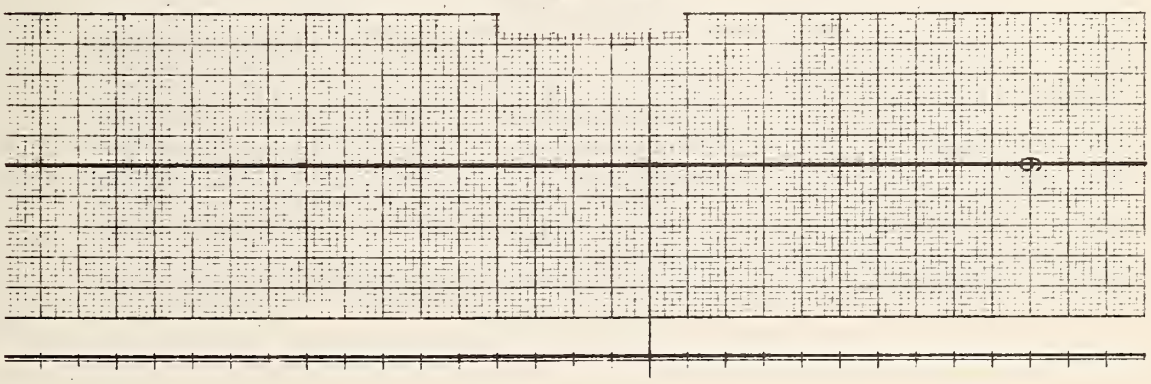

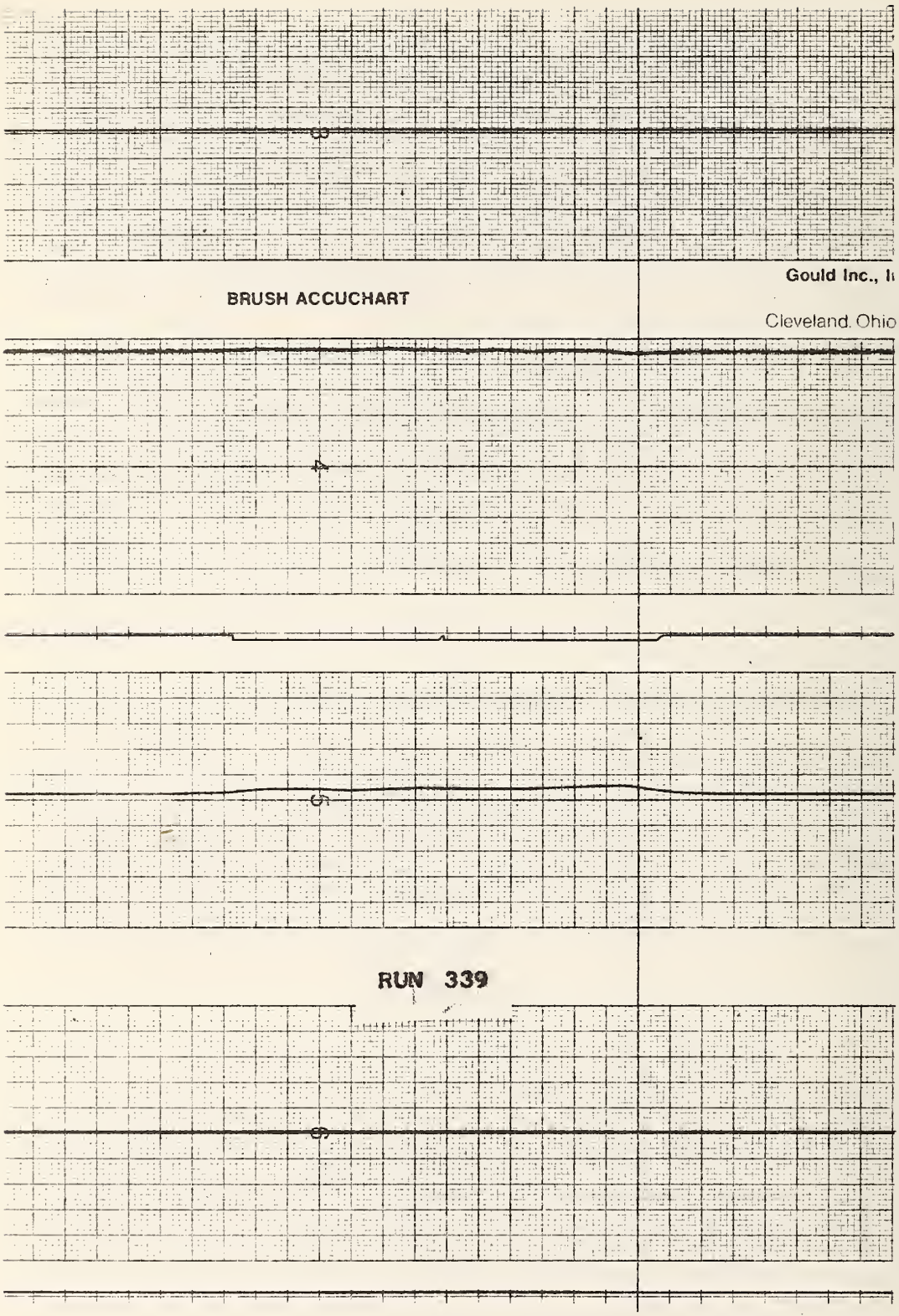
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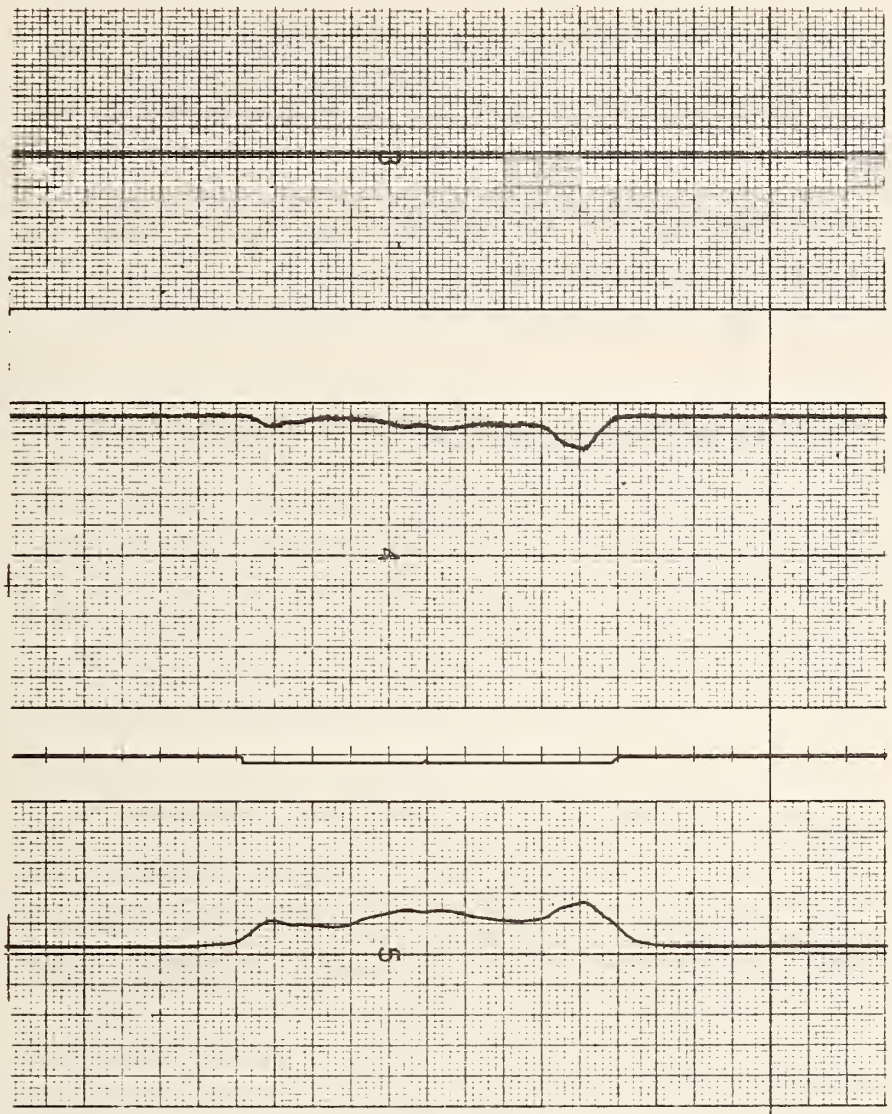
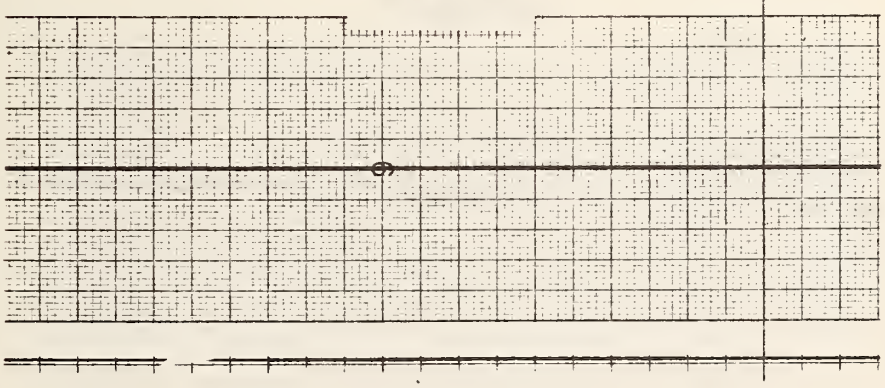
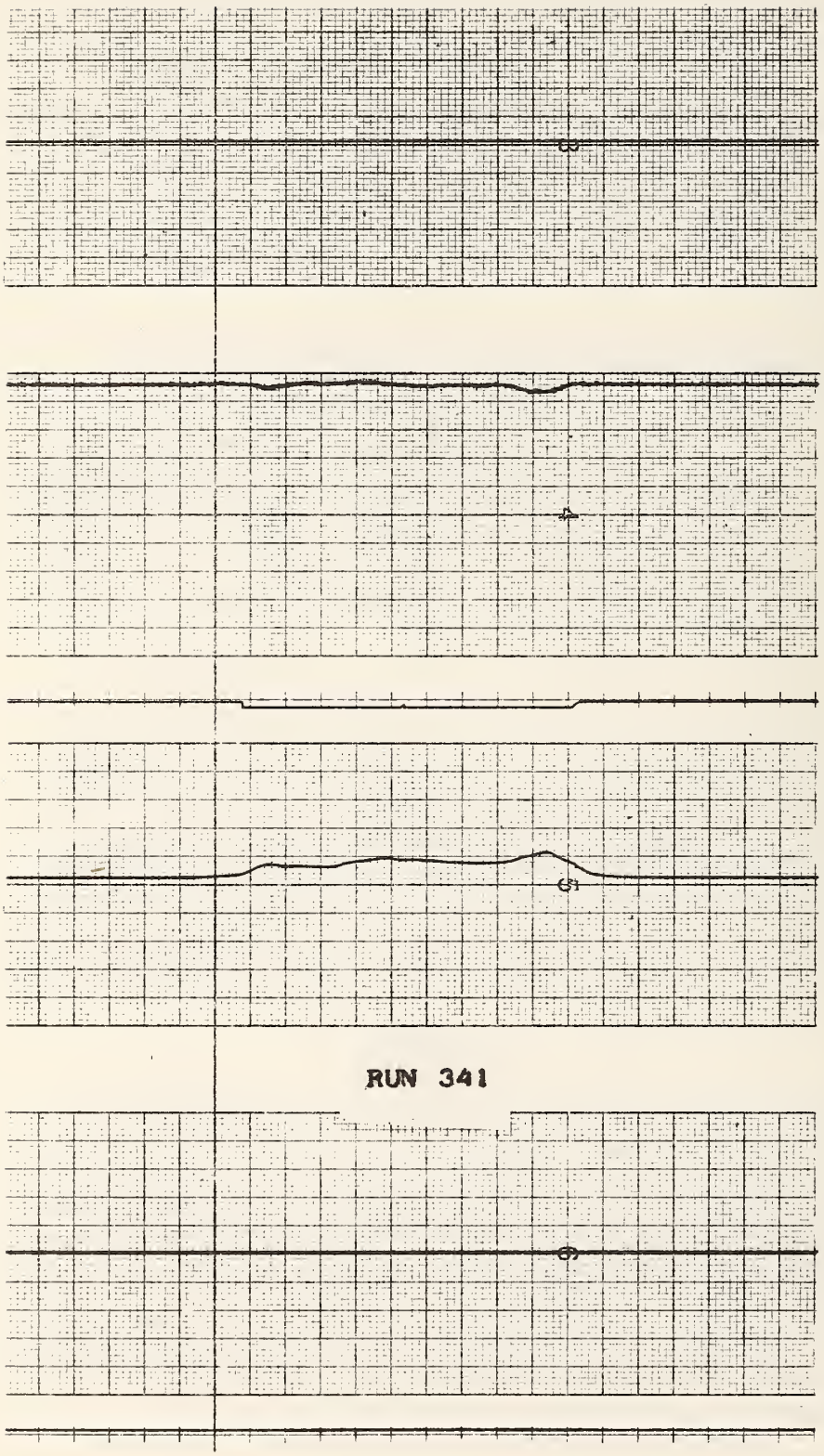
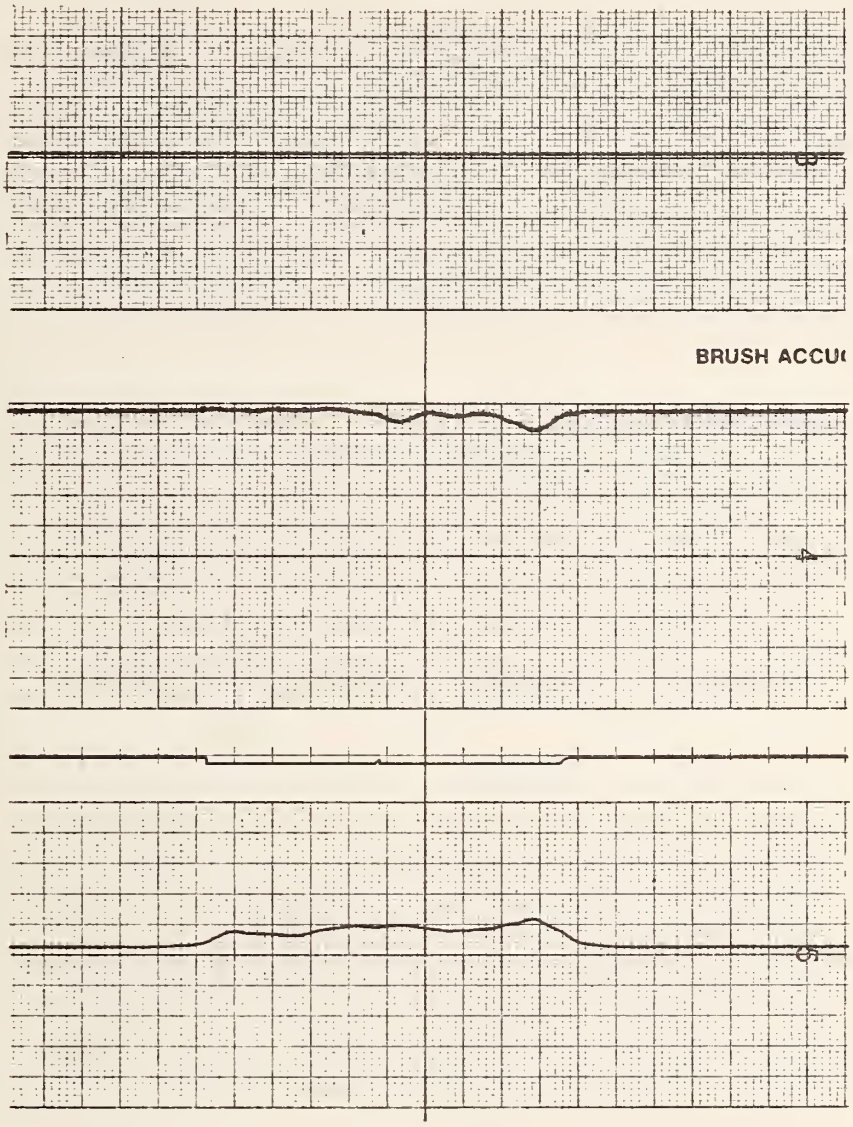
RUN 339



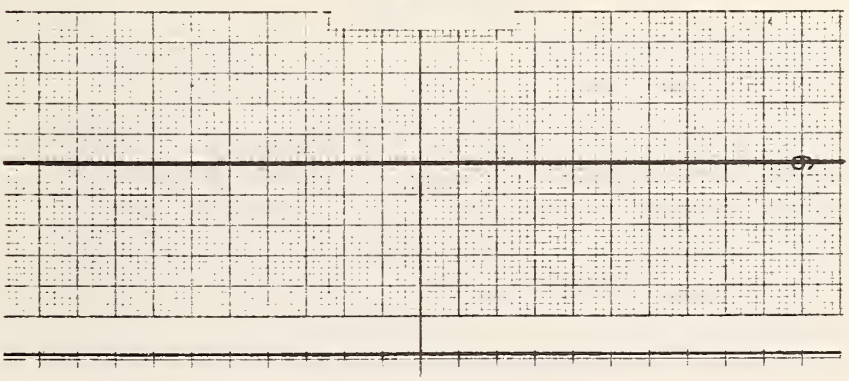
RUN 340

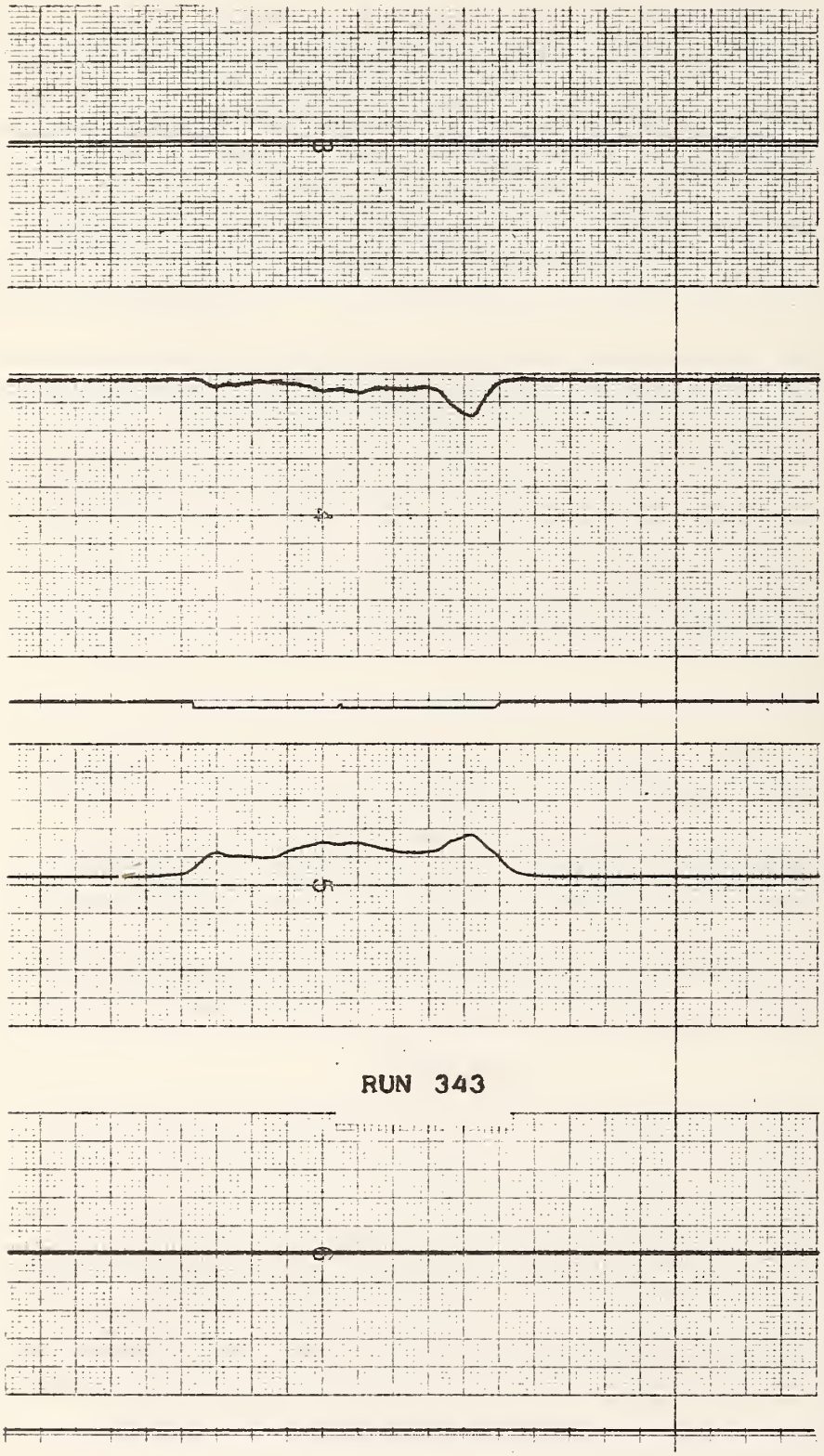



RUN 341

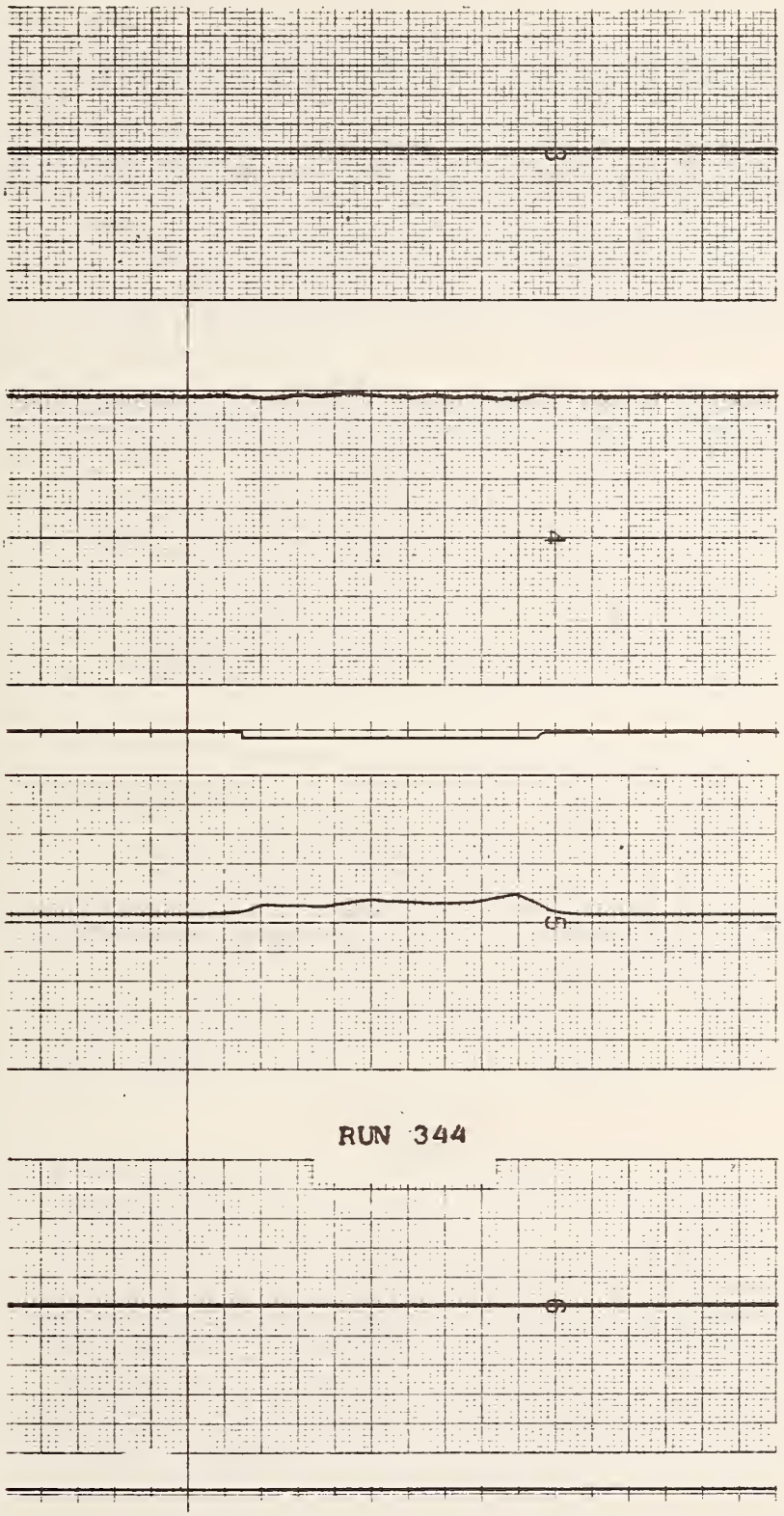


RUN 342





RUN 343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RUN 344
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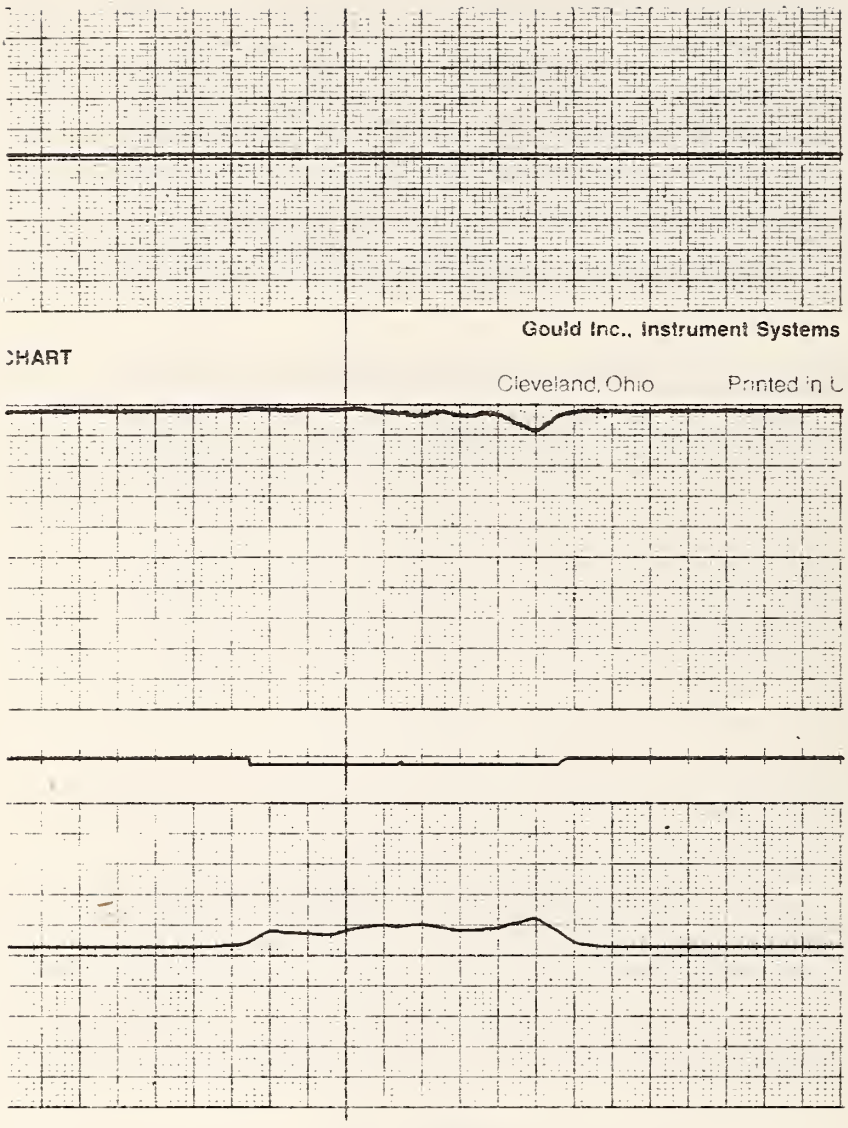
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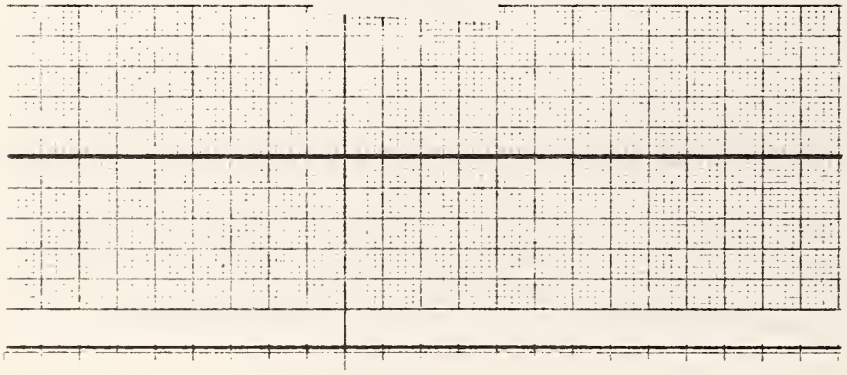
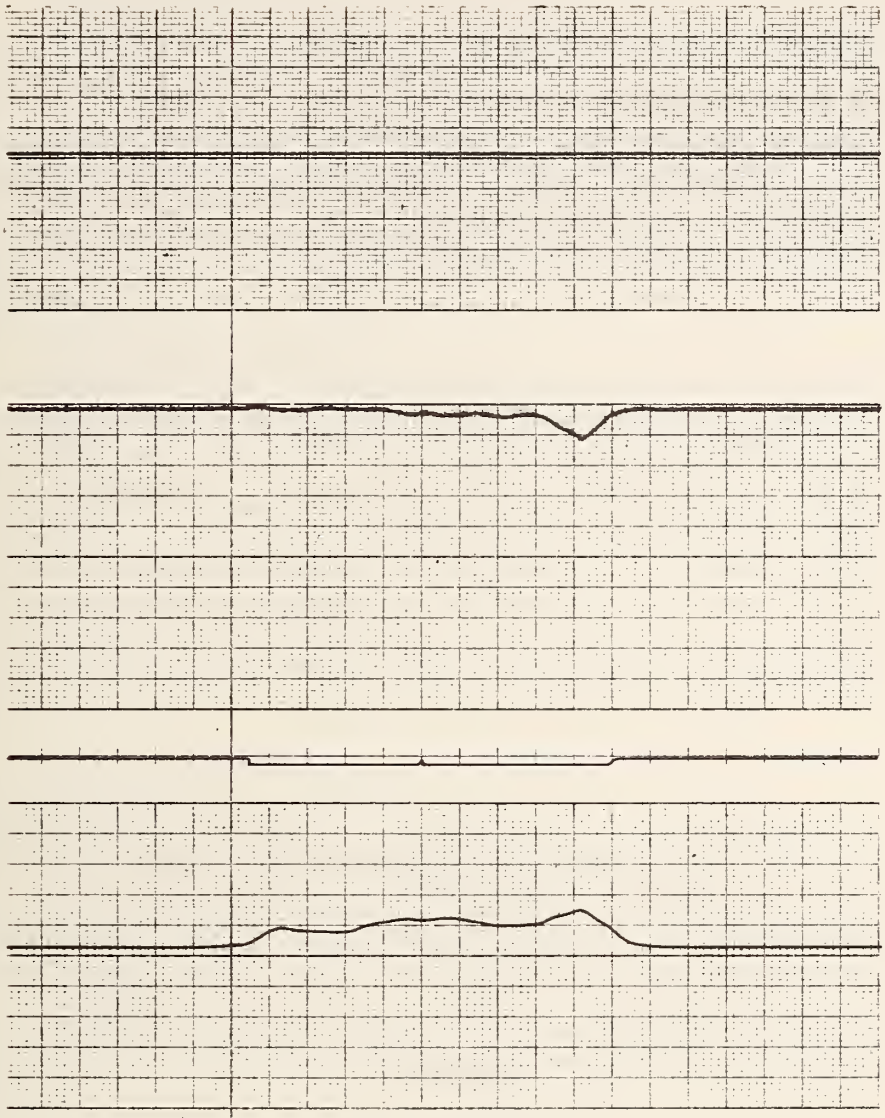
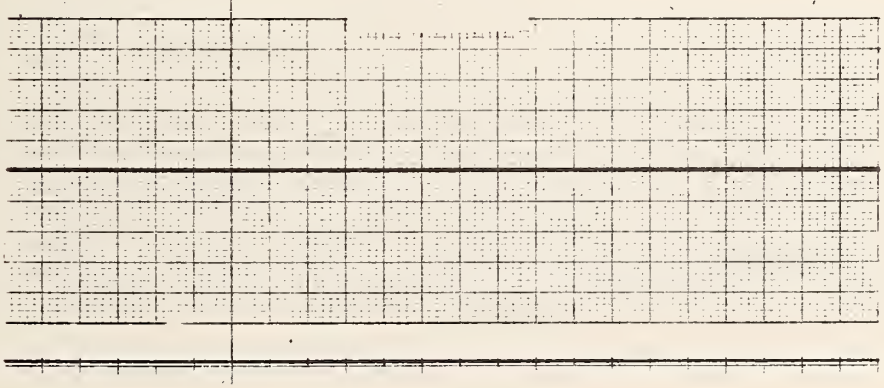
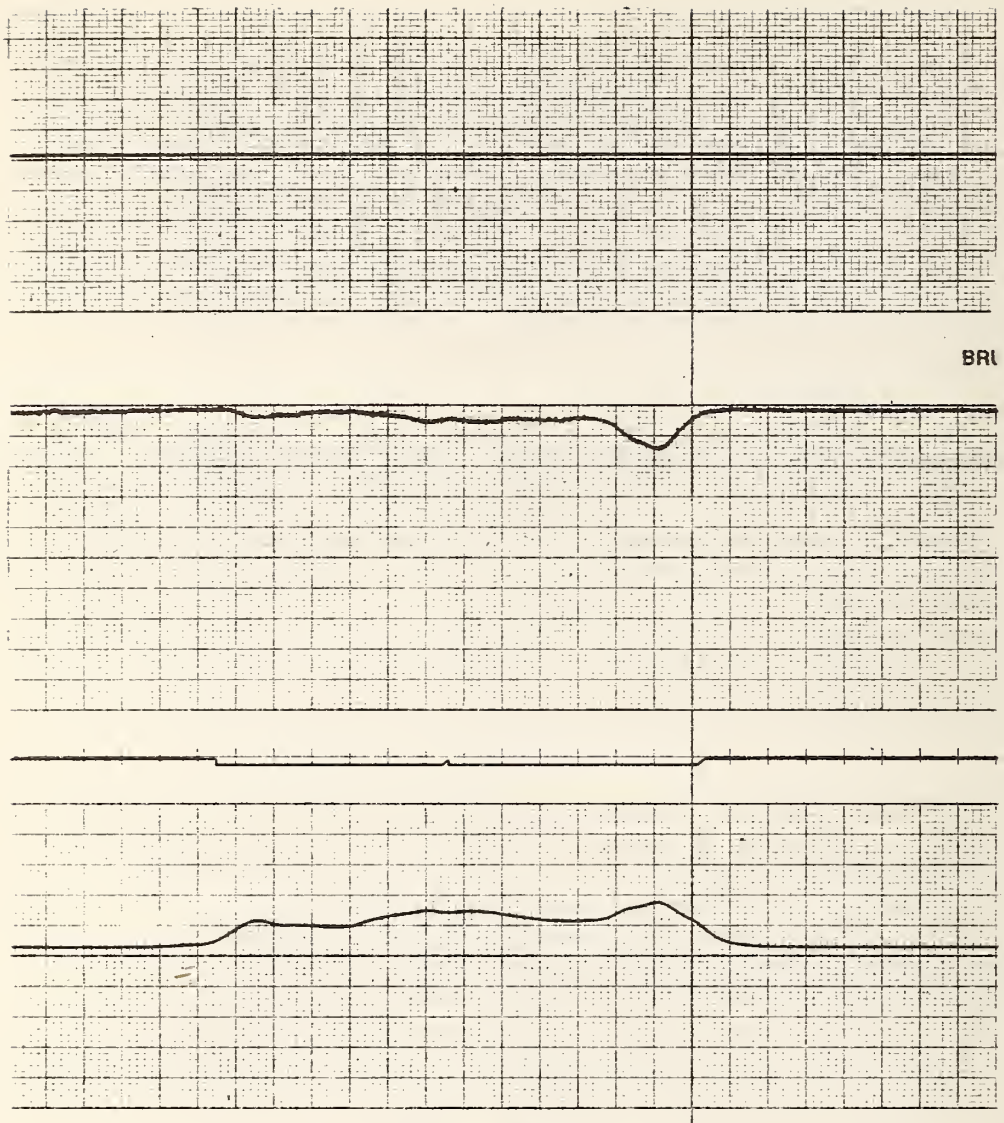


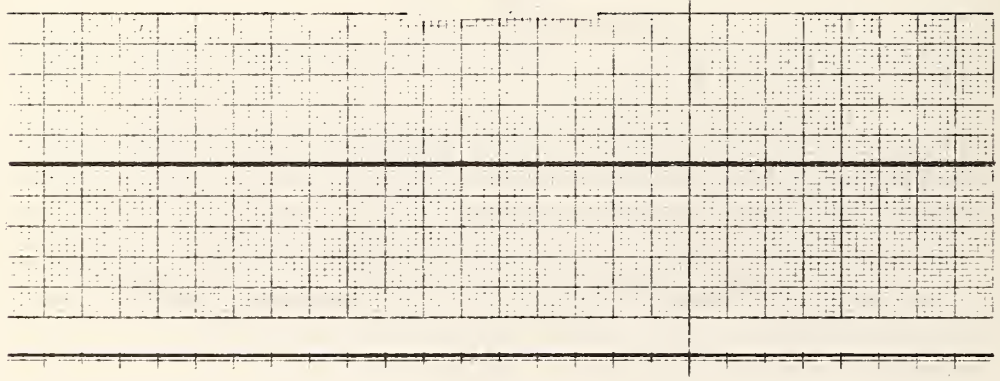


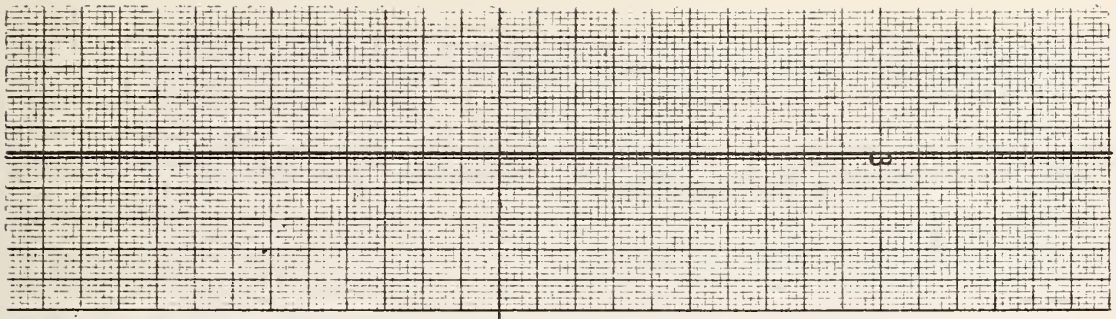
RUN 346





RUN 347





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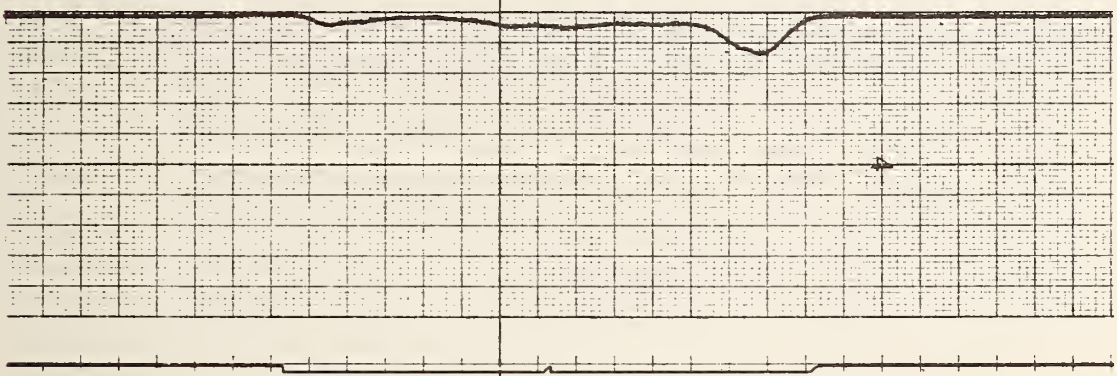

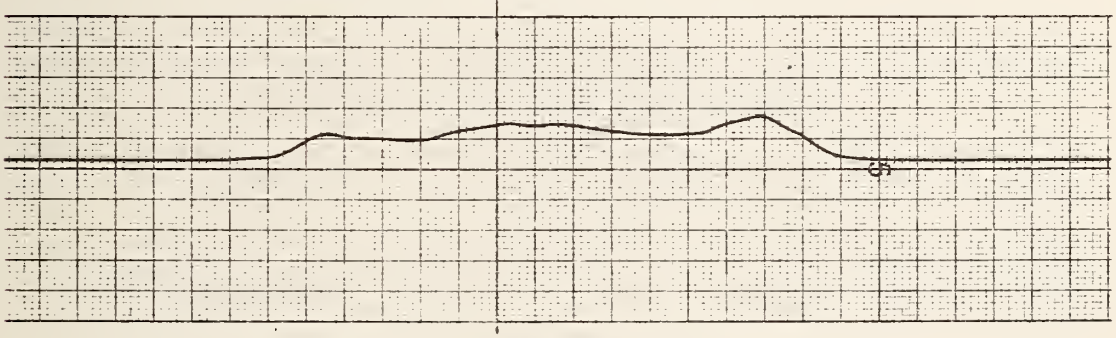

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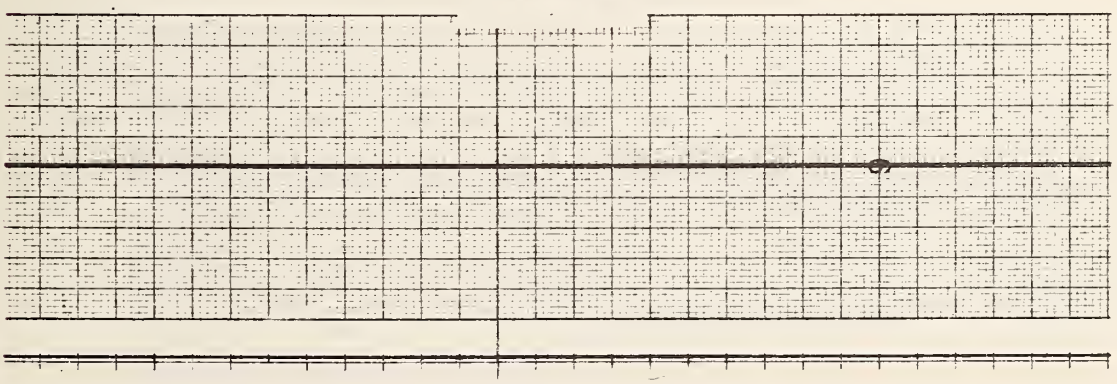

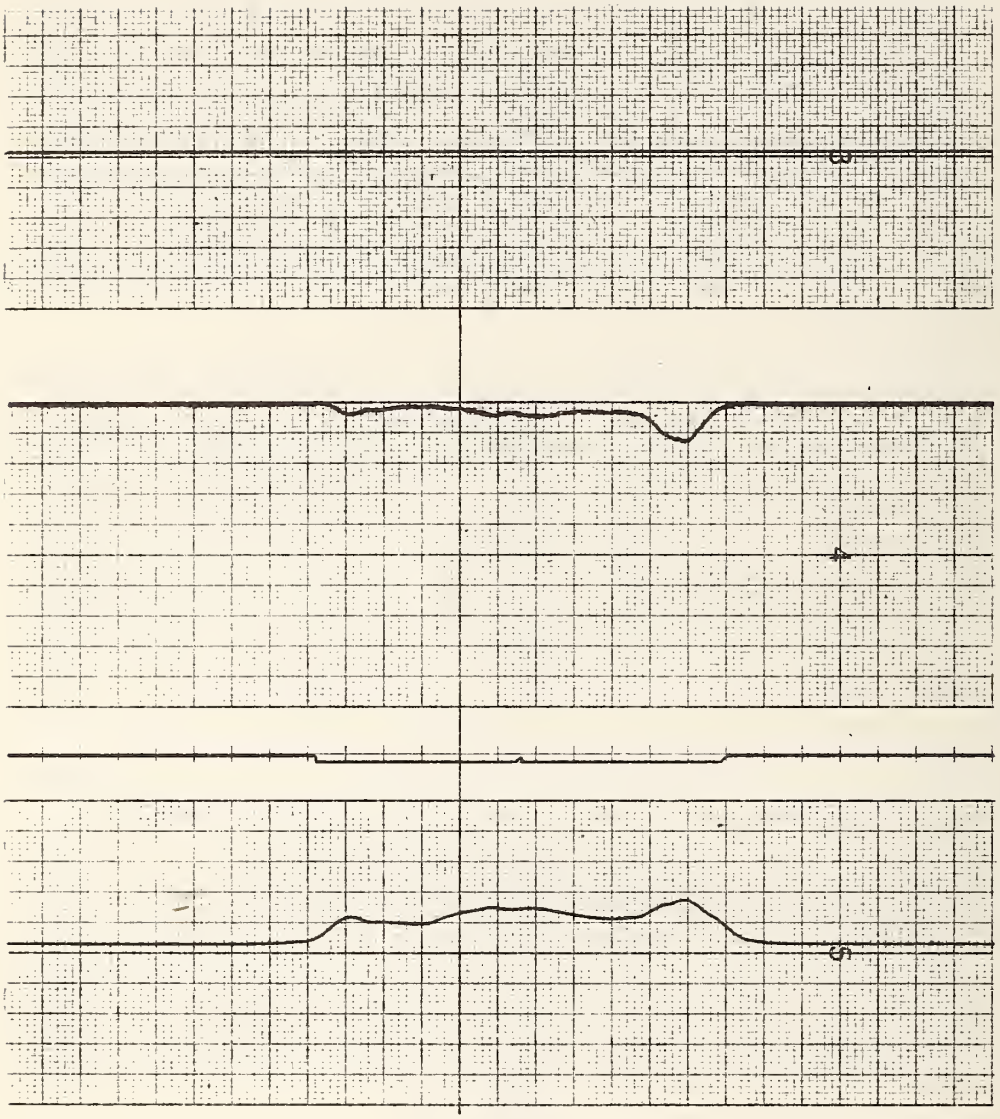

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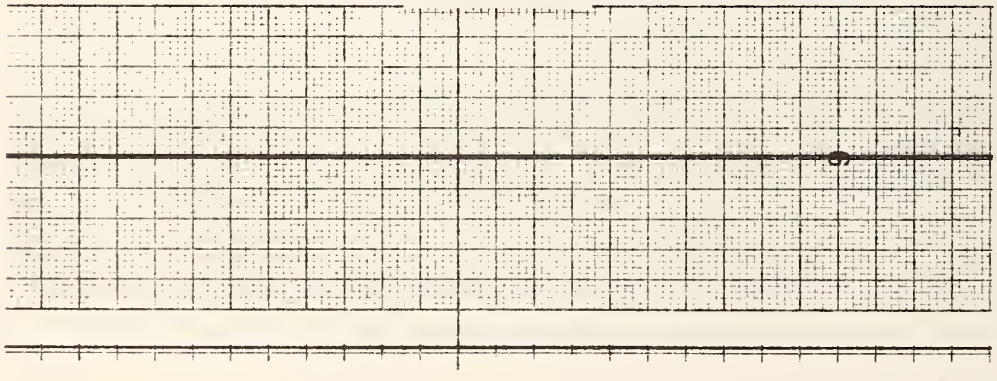

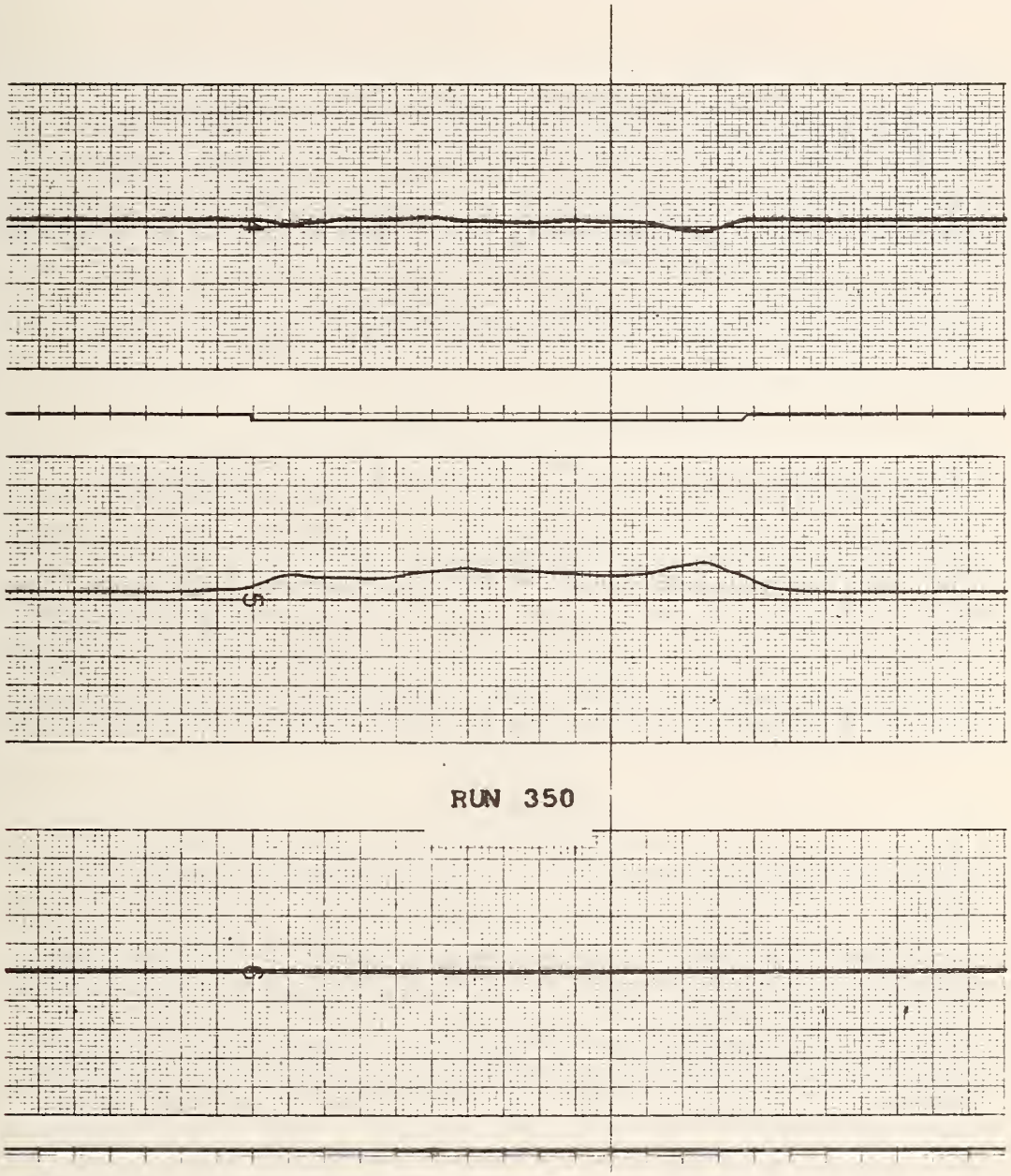
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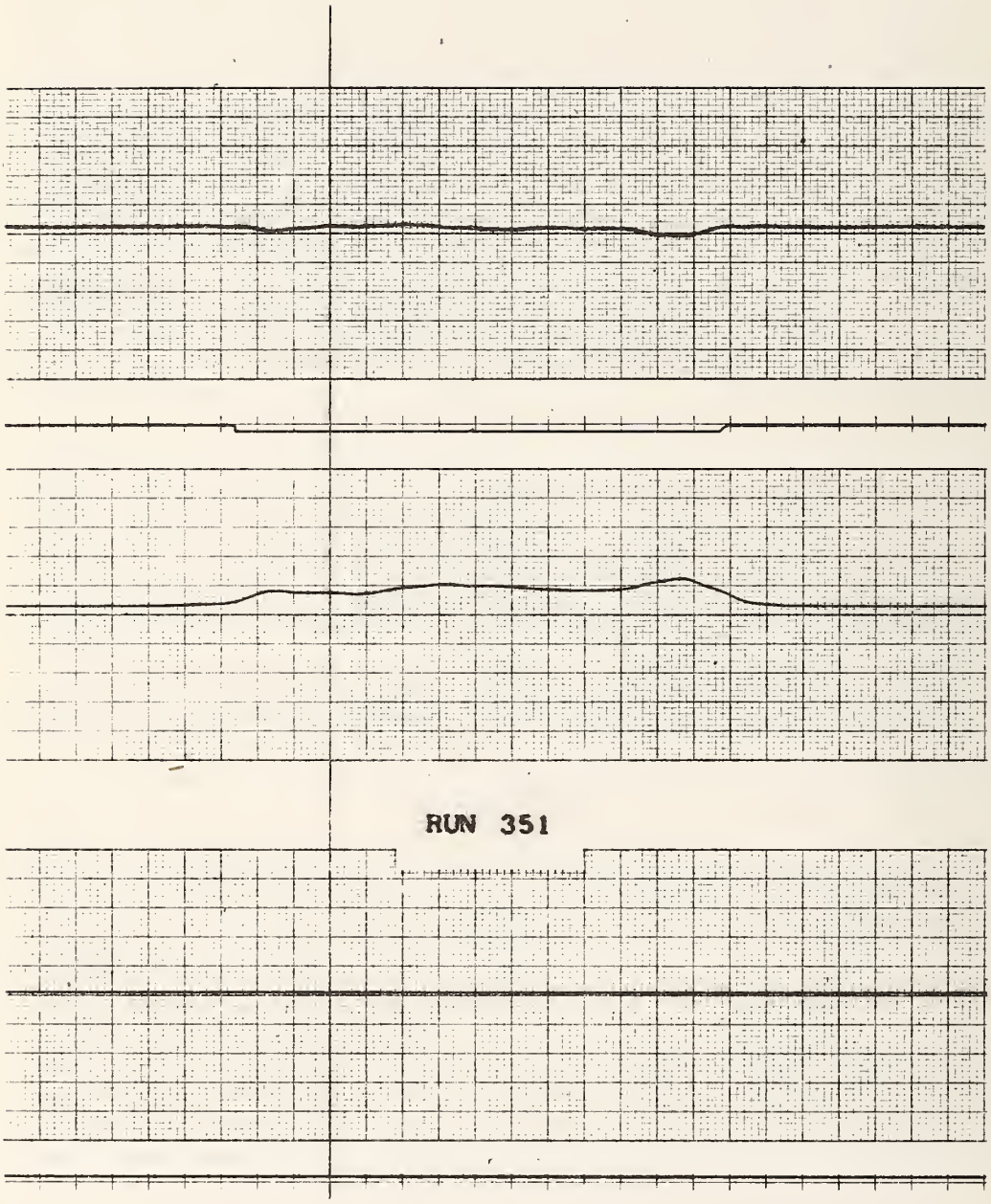

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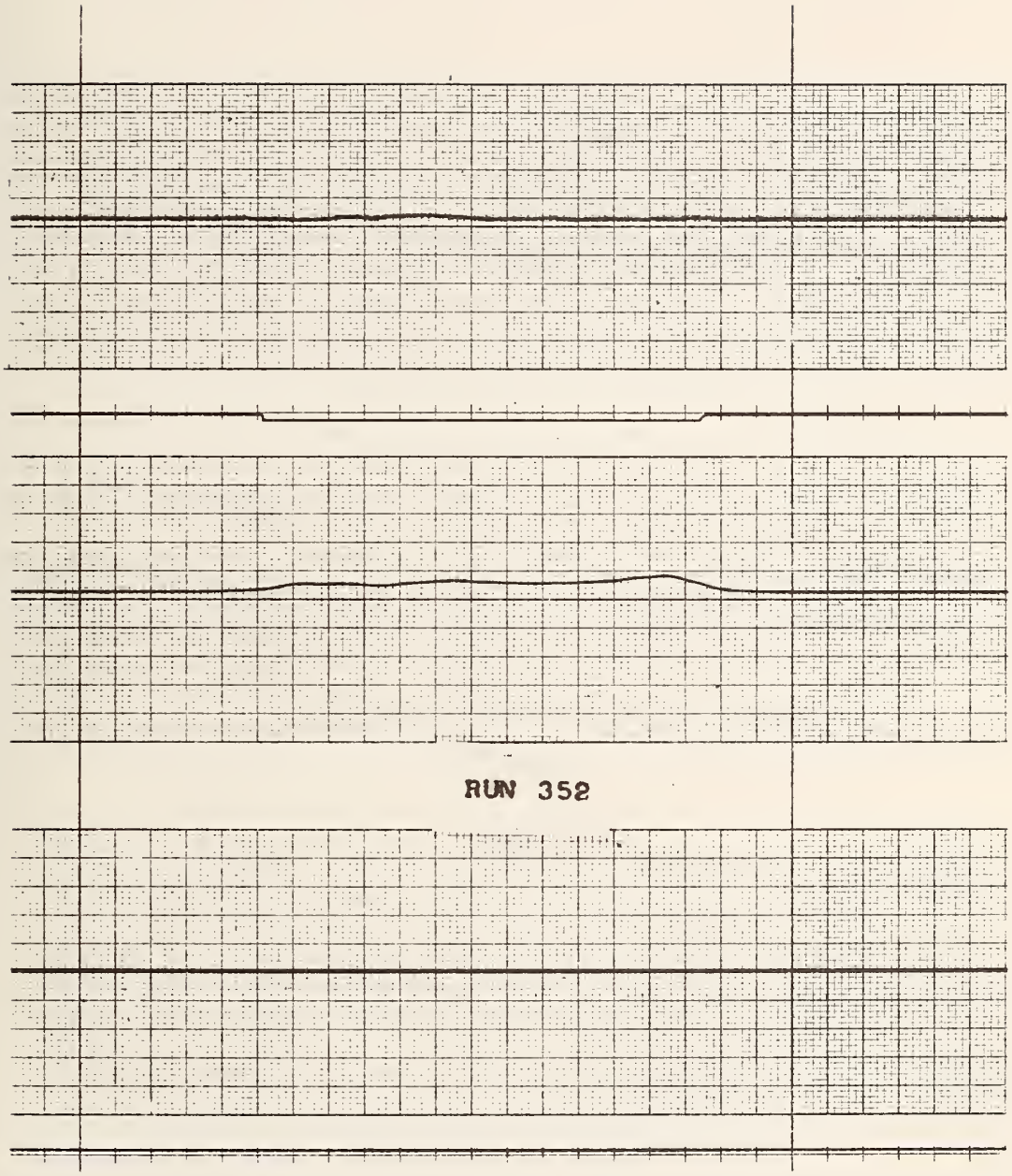
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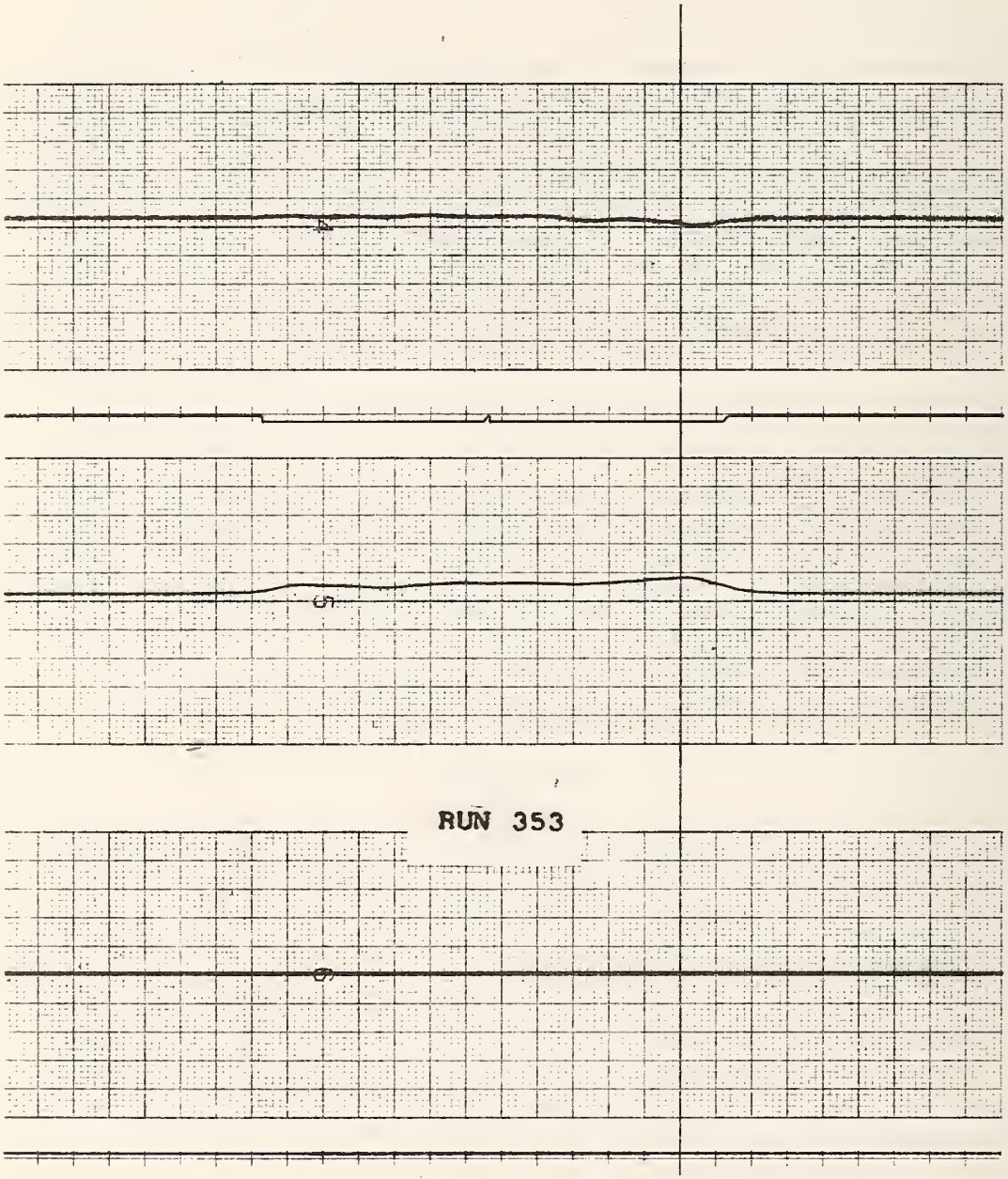
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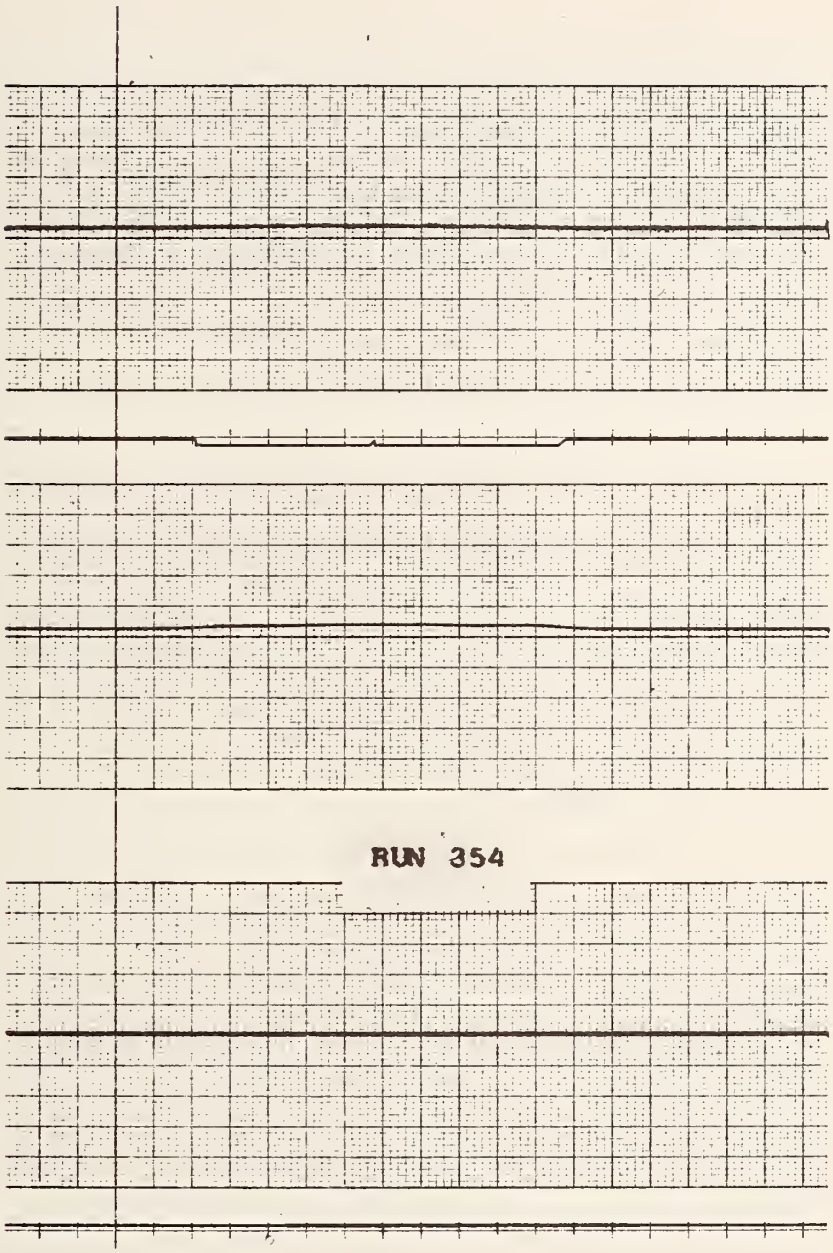
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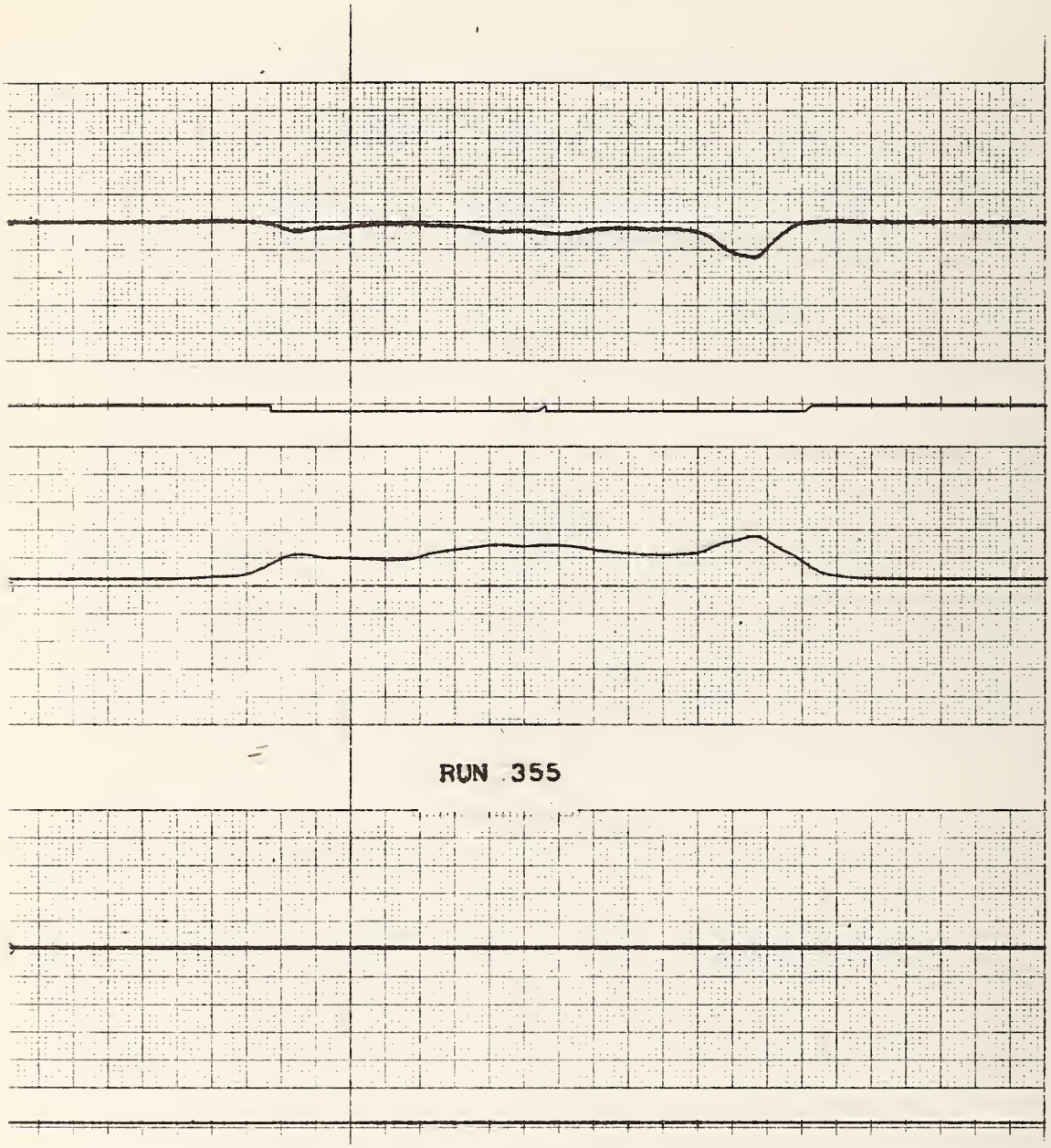
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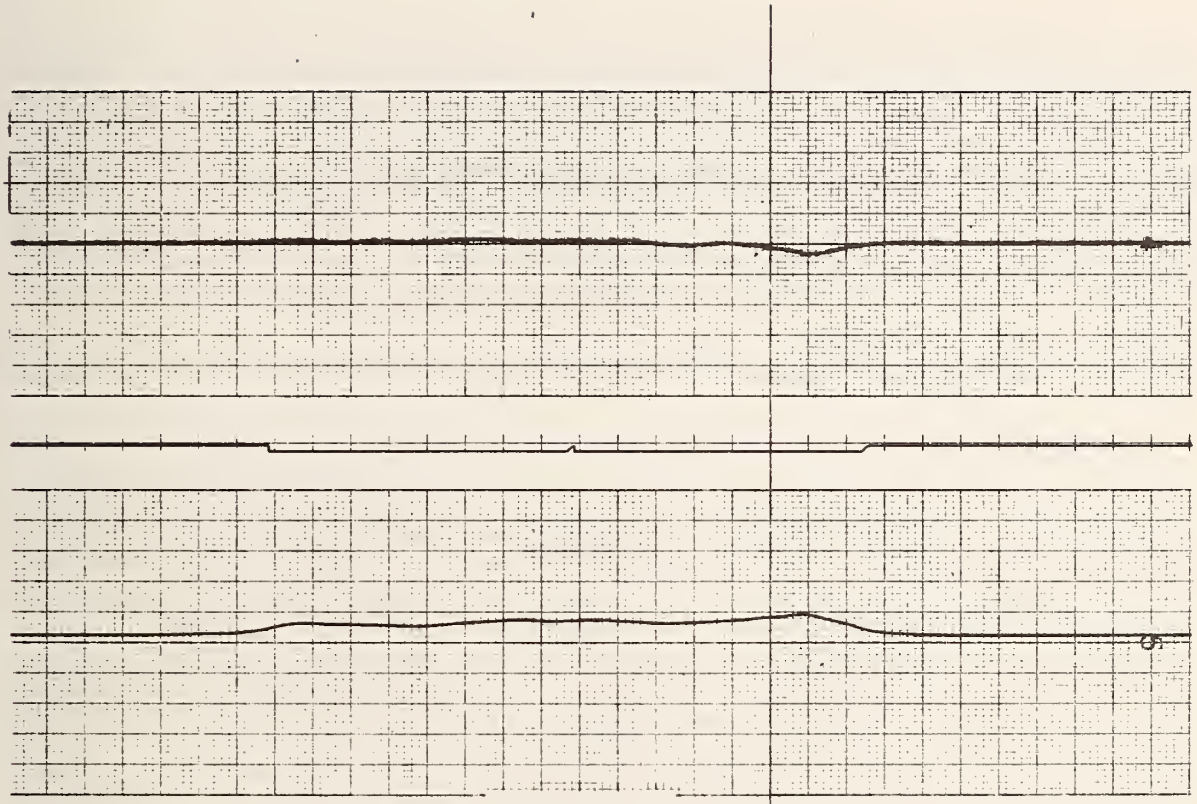

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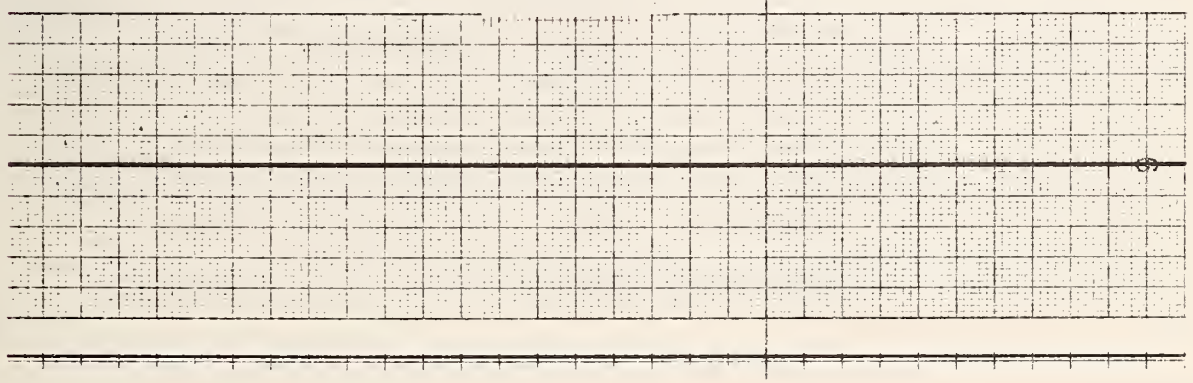

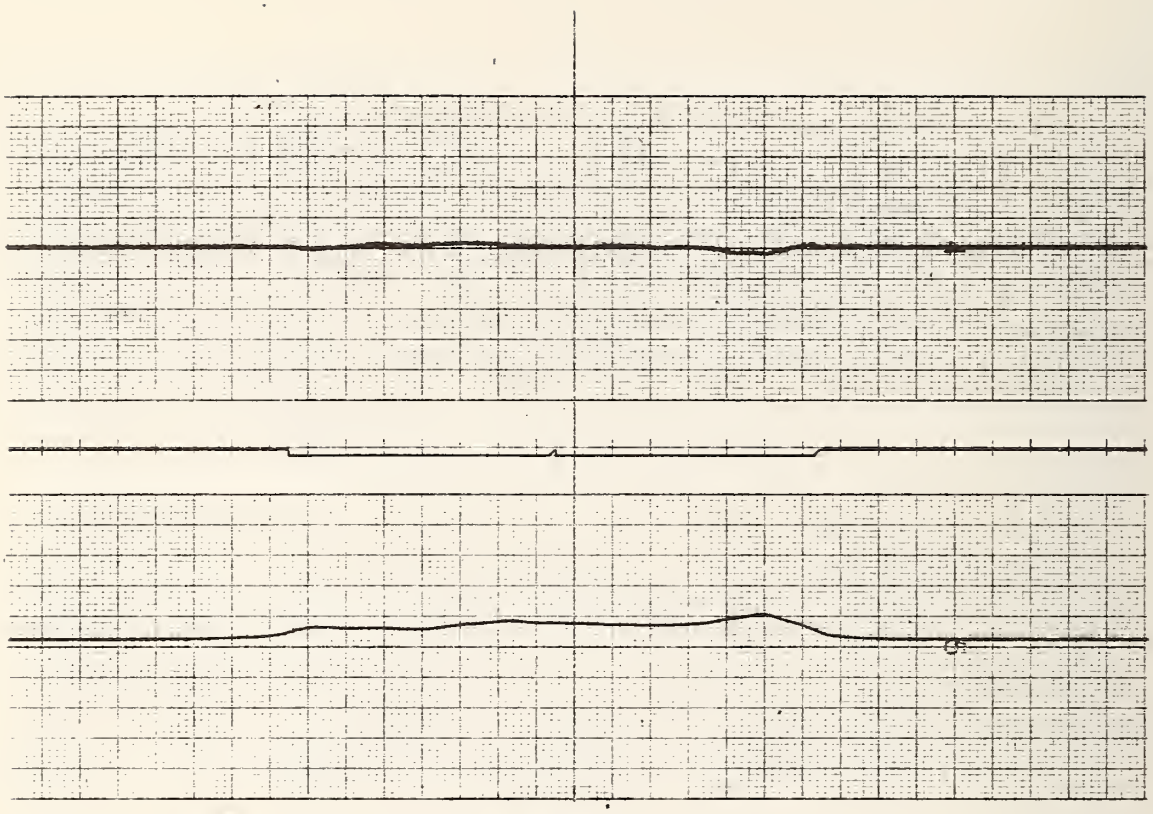

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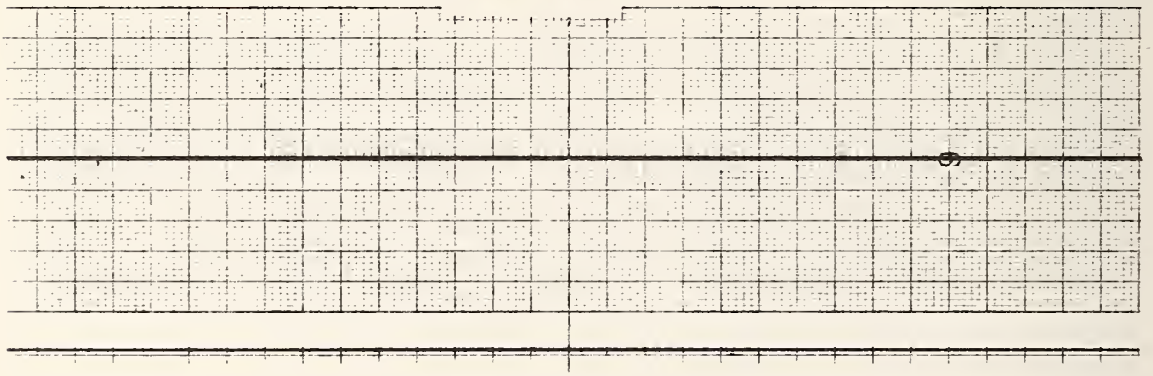

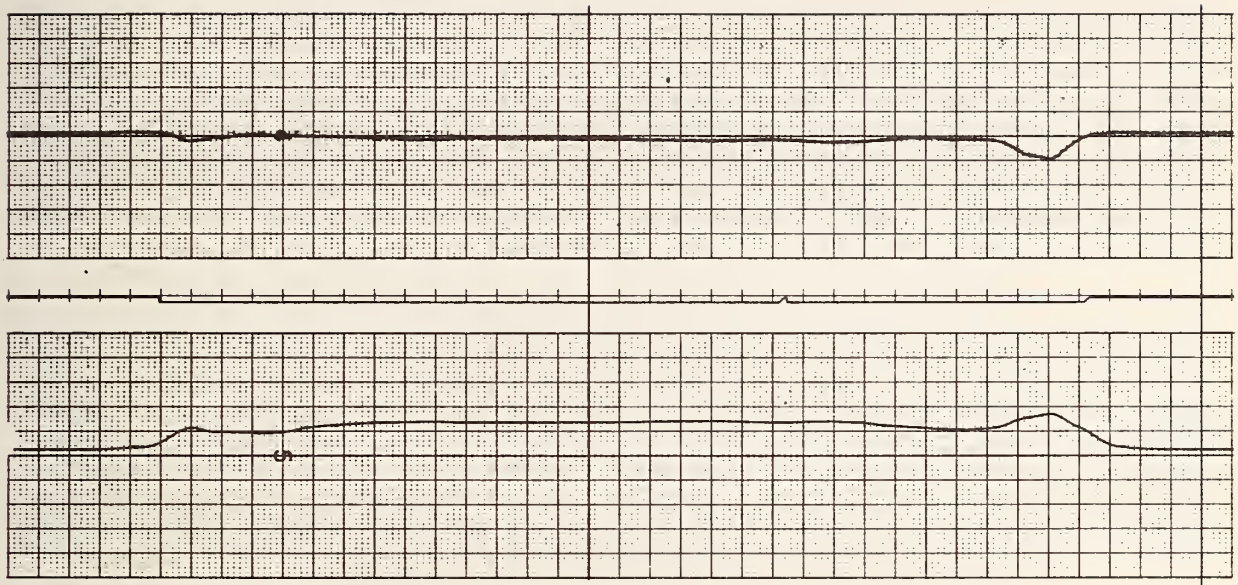

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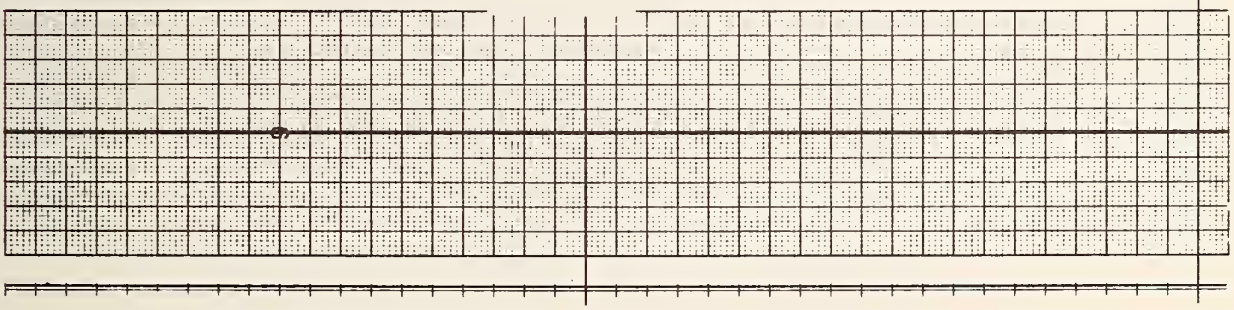

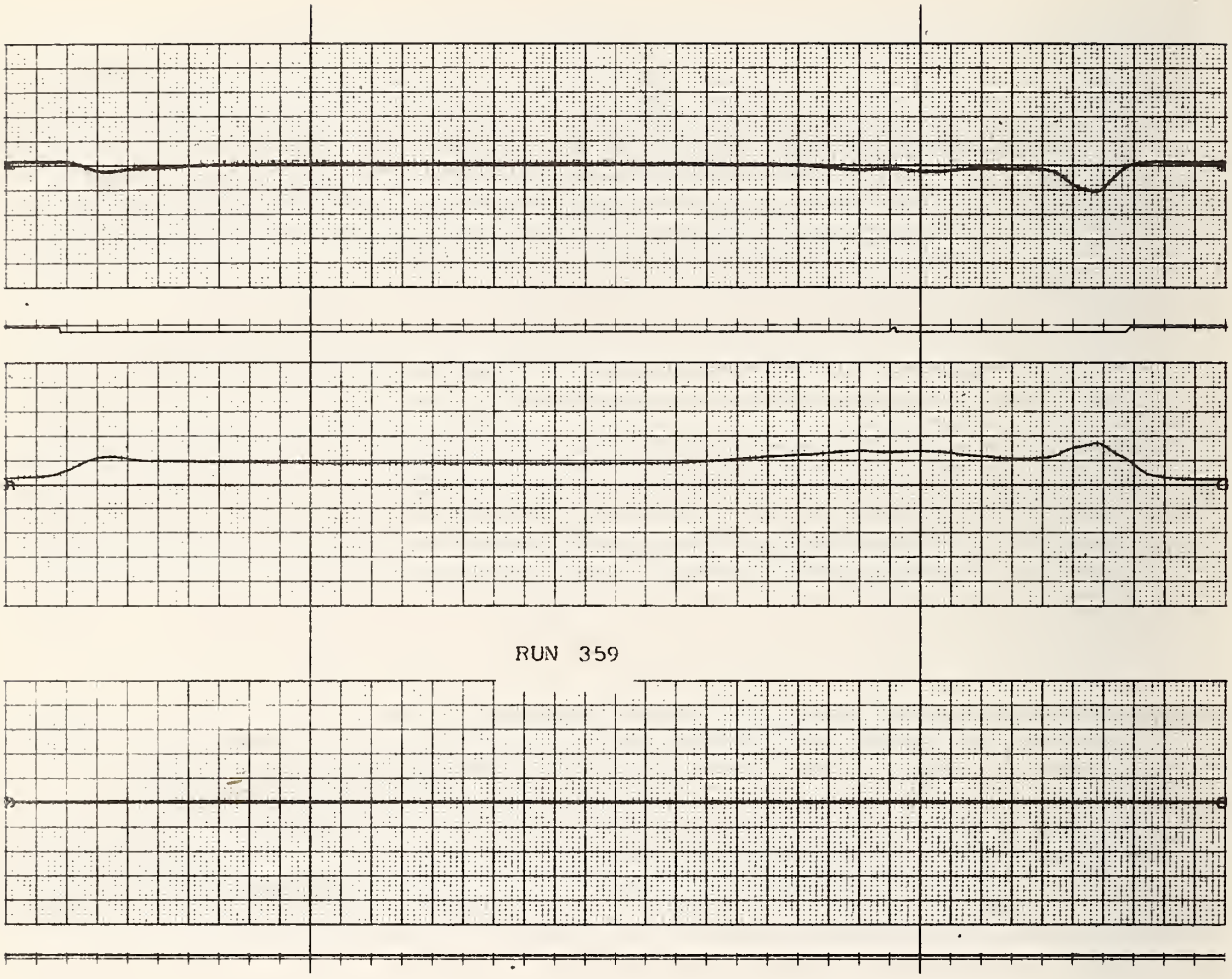
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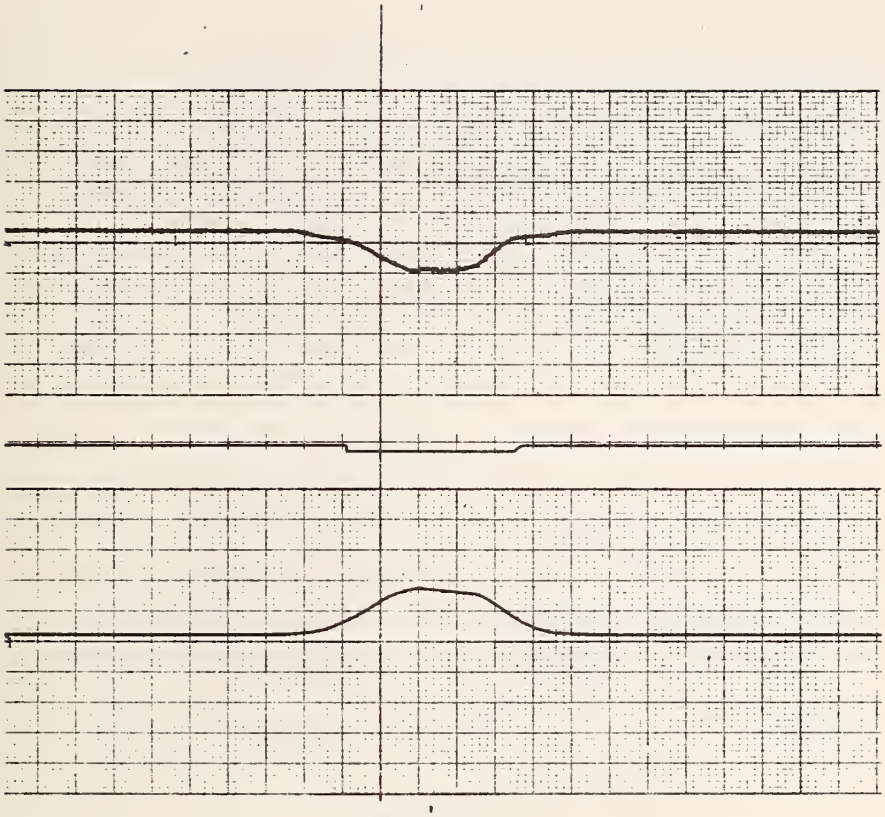
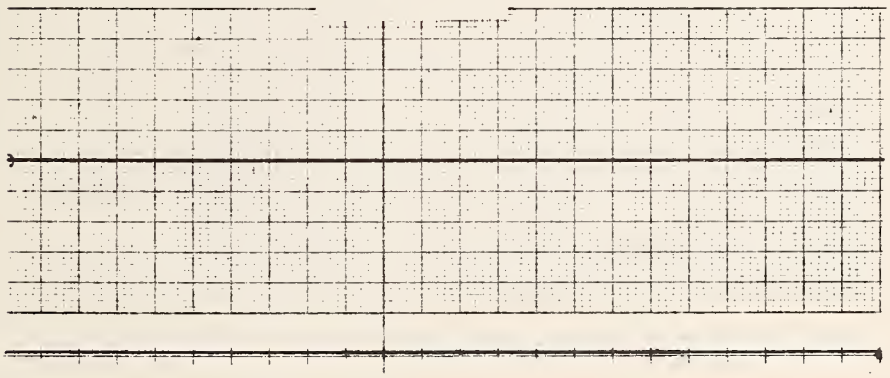
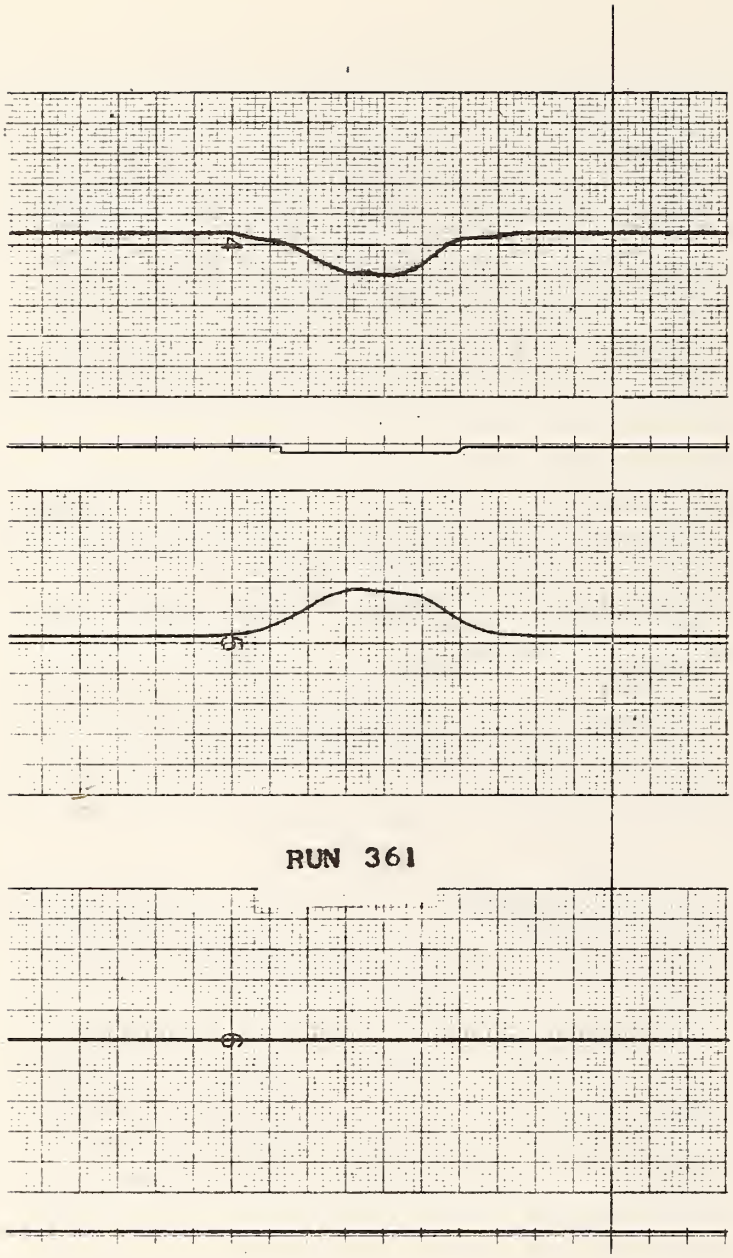


RUN 360





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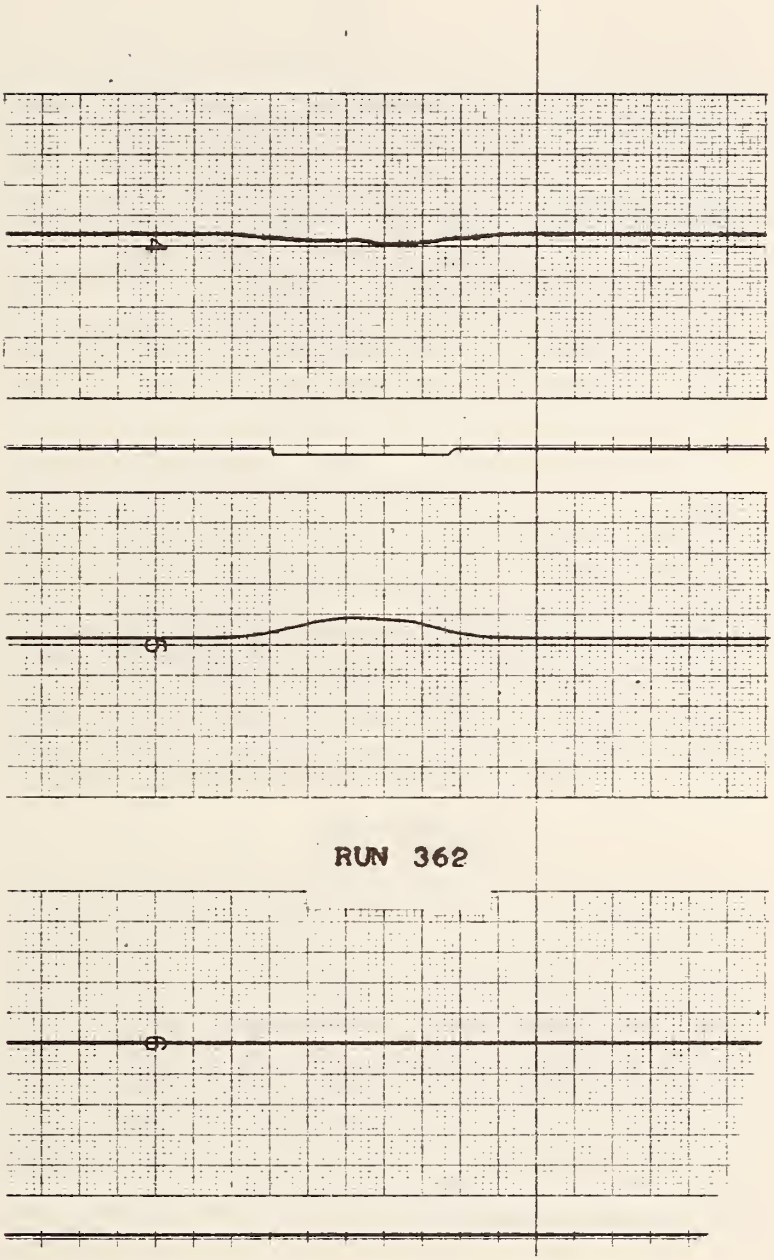
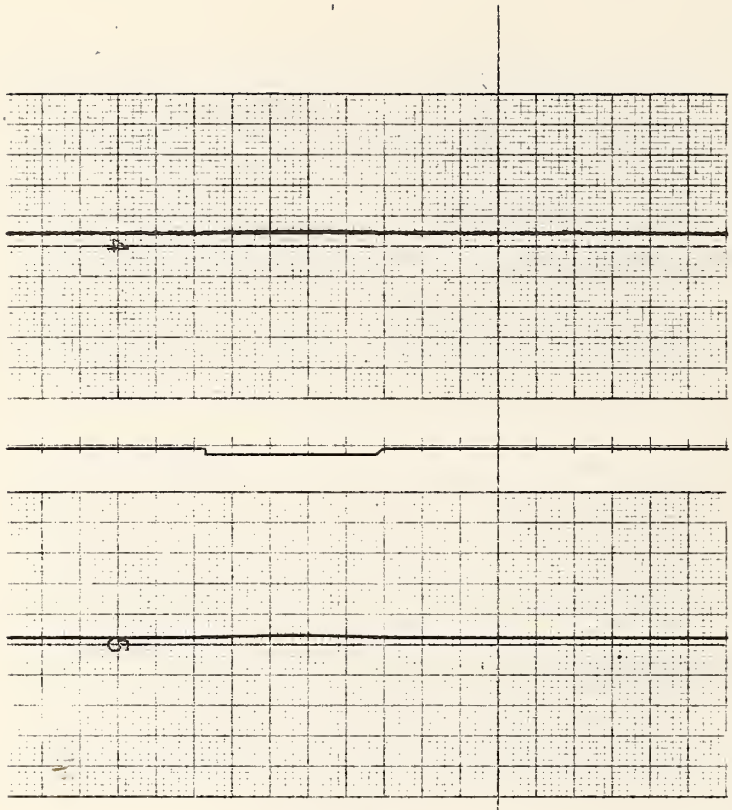
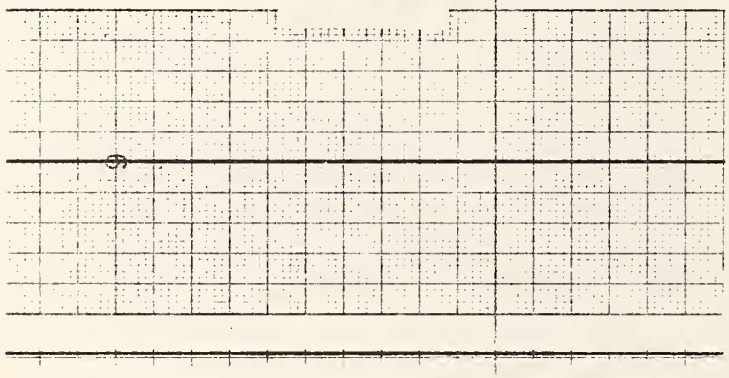
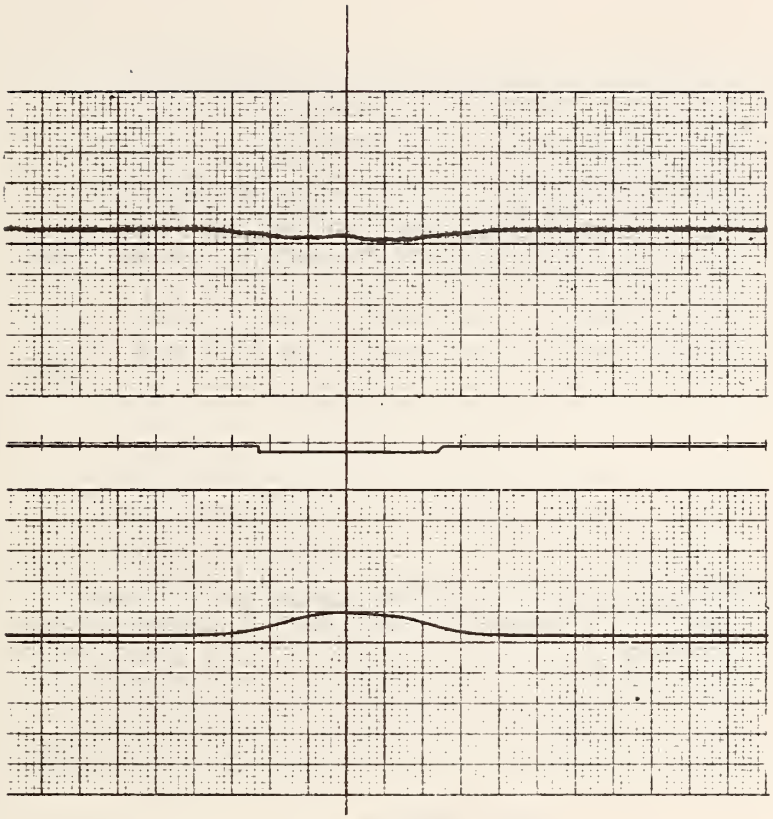


RUN 362



RUN 363





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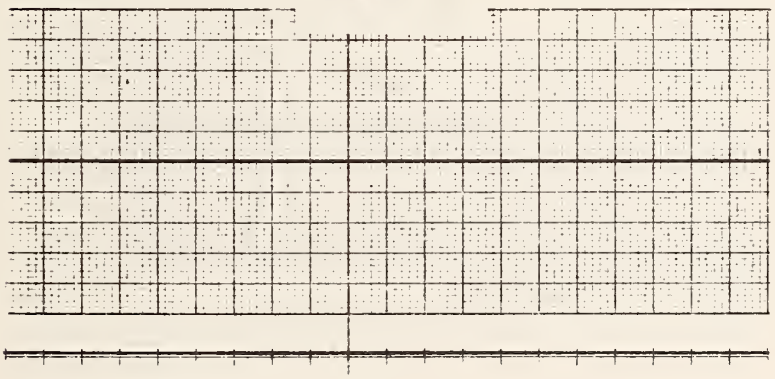
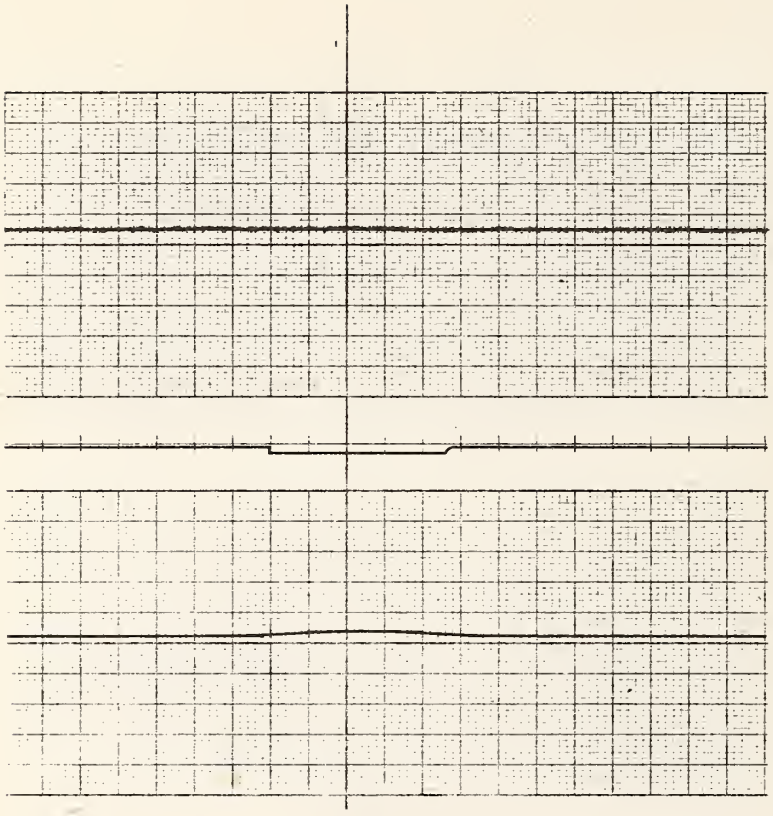
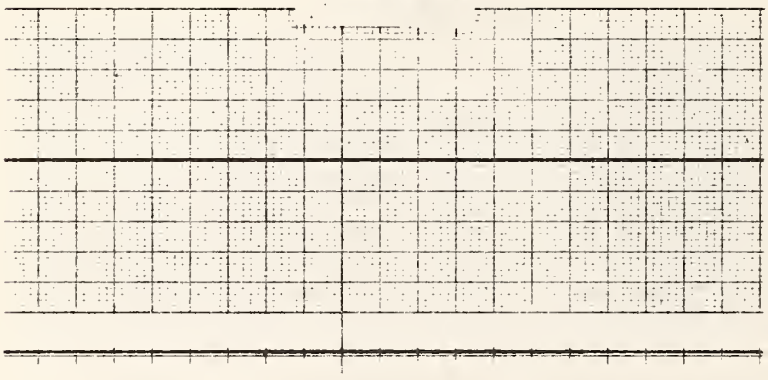




RUN 365



Runs 366-394

From top to bottom:

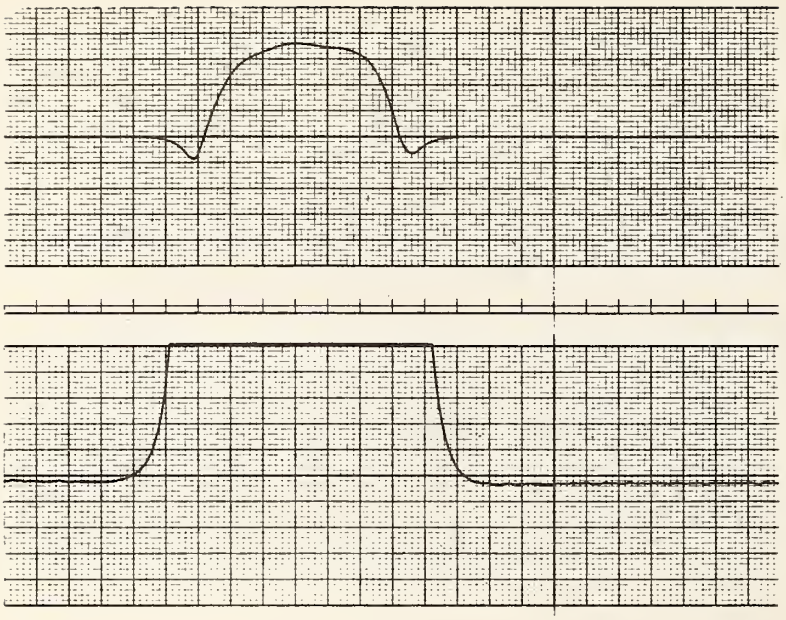
Trace 1 = MGVD amplitude

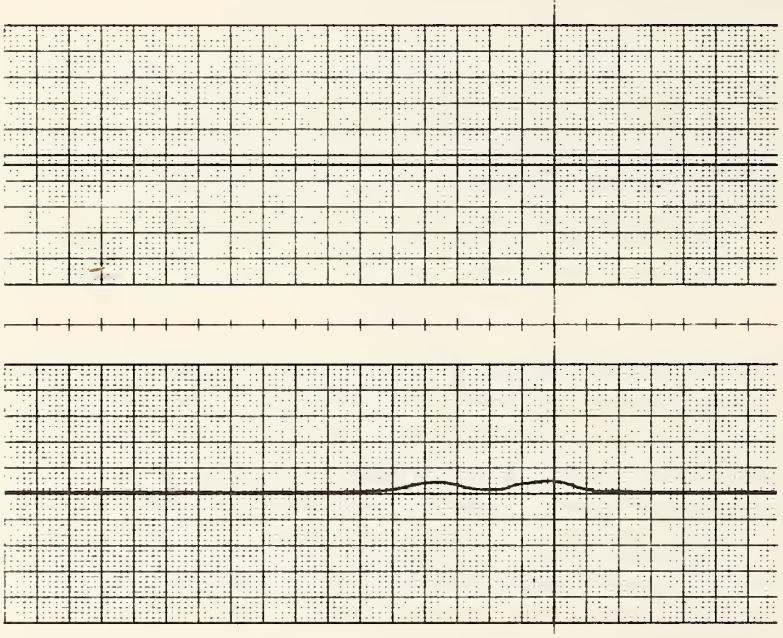
Trace 2 = MGVD phase

Trace 3 = N/A

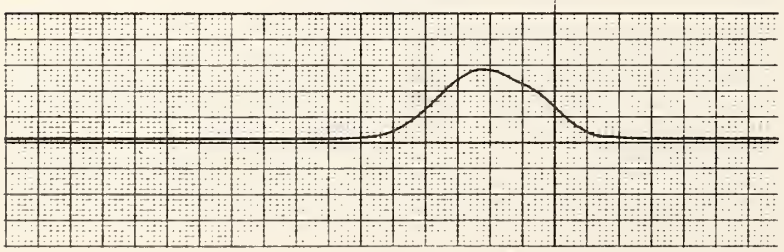
Trace 4 = ILD amplitude

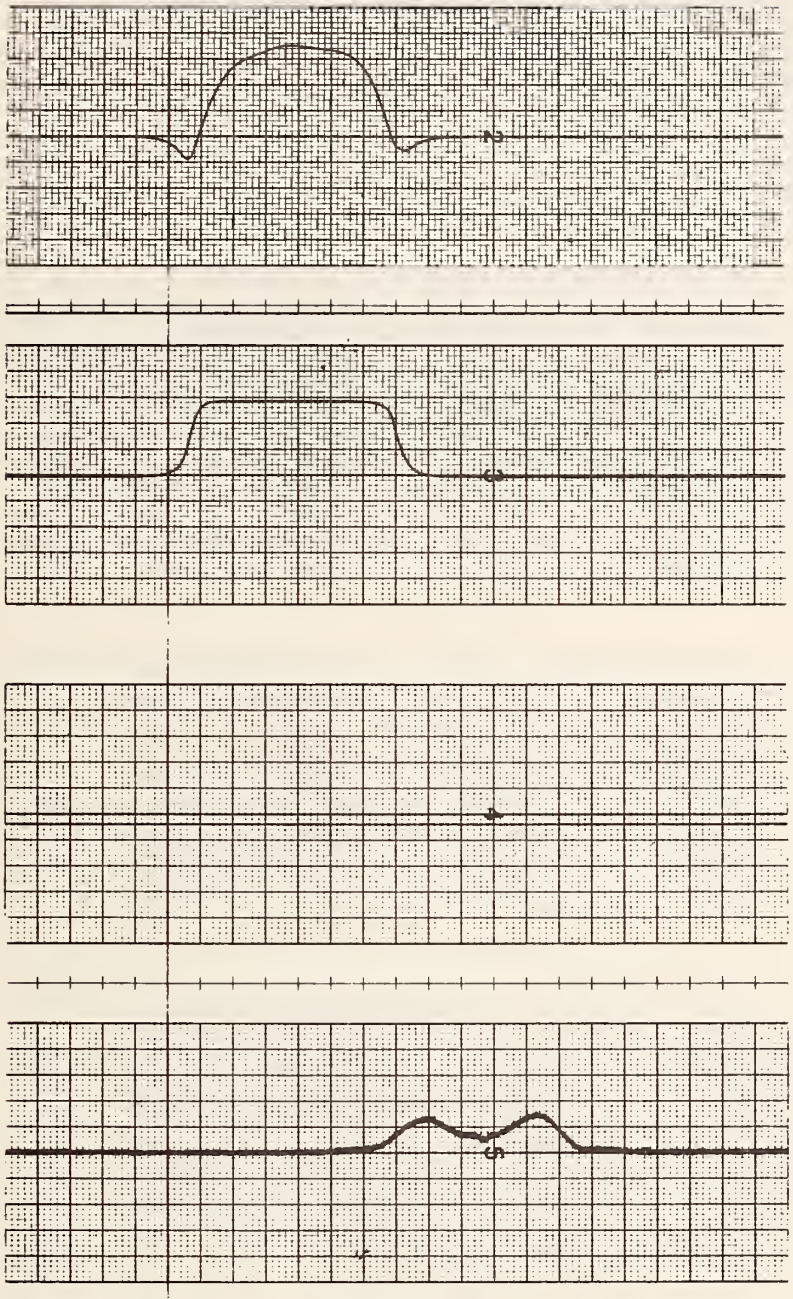
Trace 5 = ILD phase



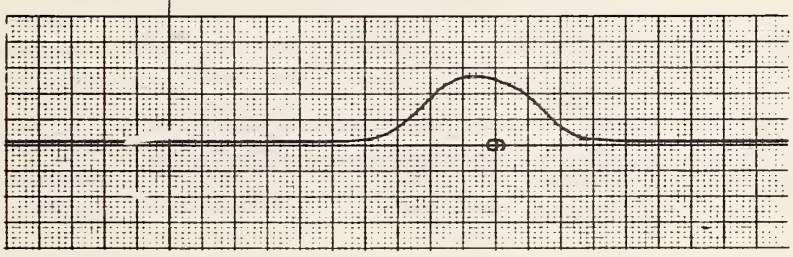


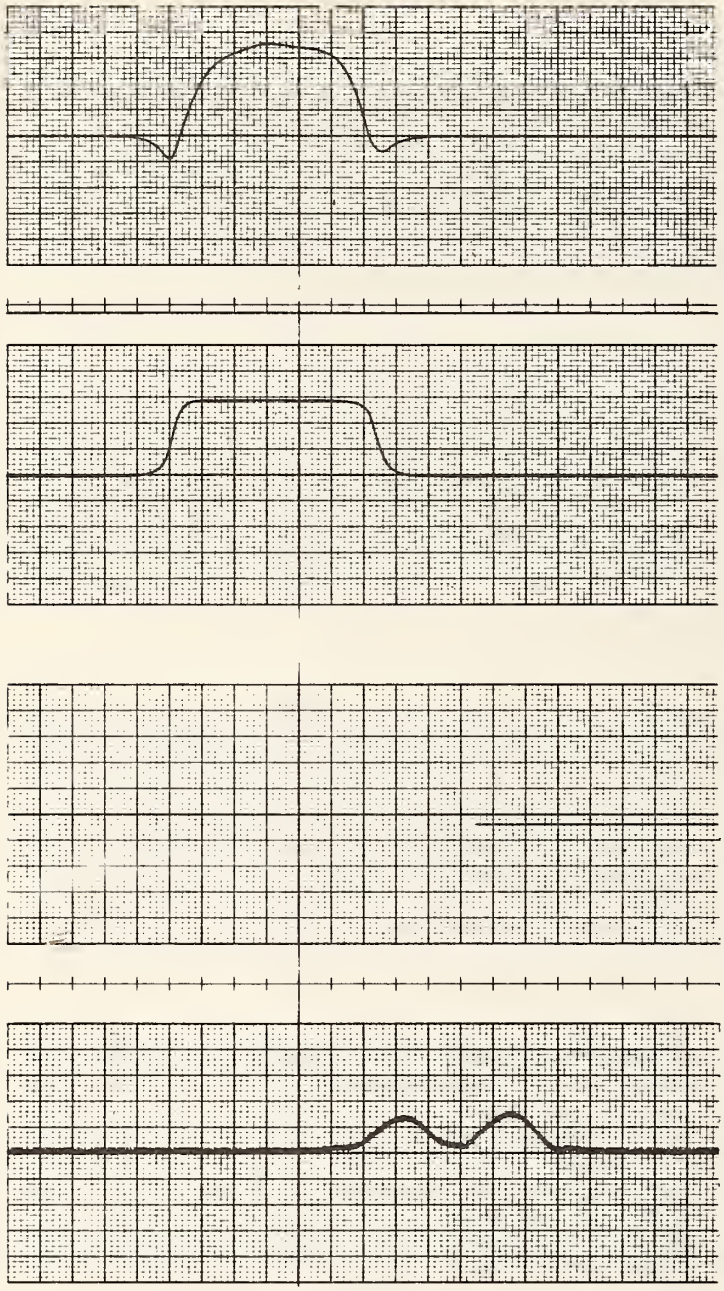
RUN 366



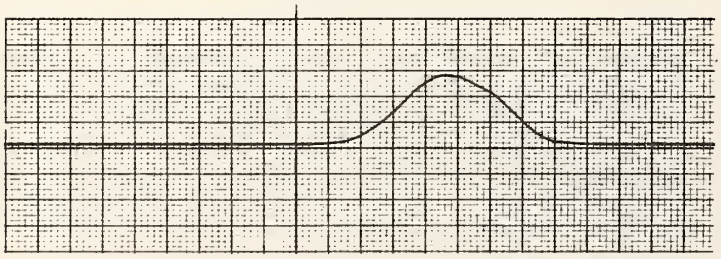


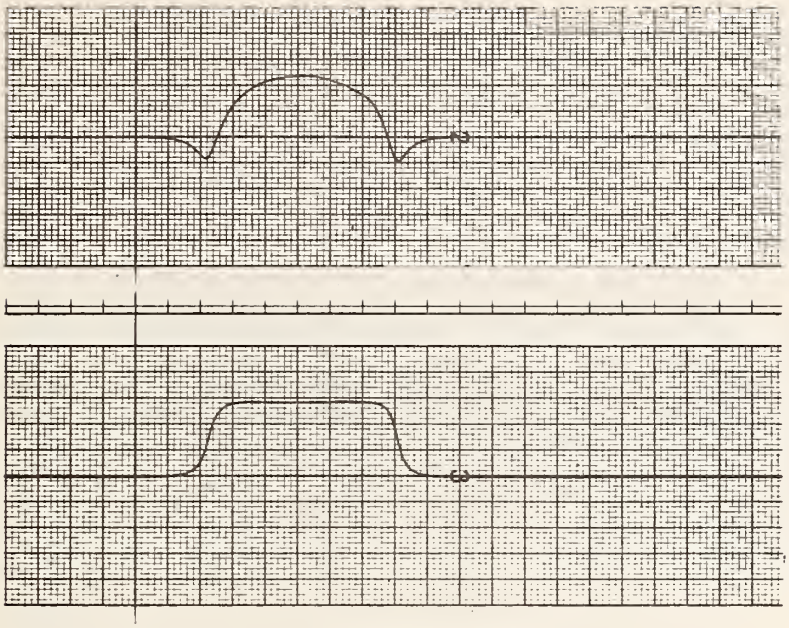
RUN 367





RUN 368





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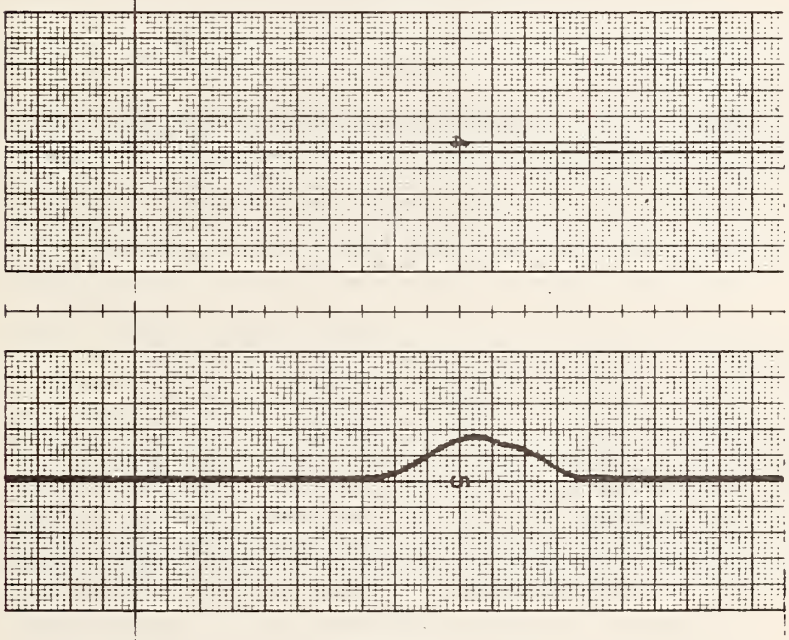
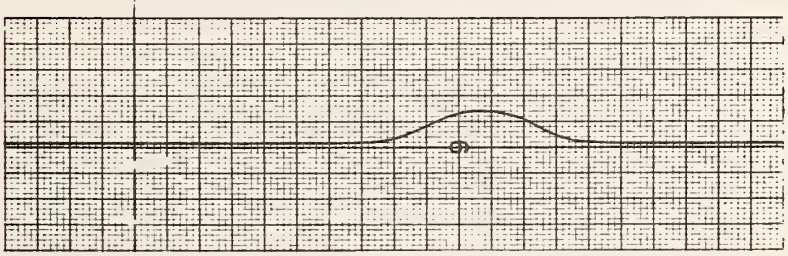
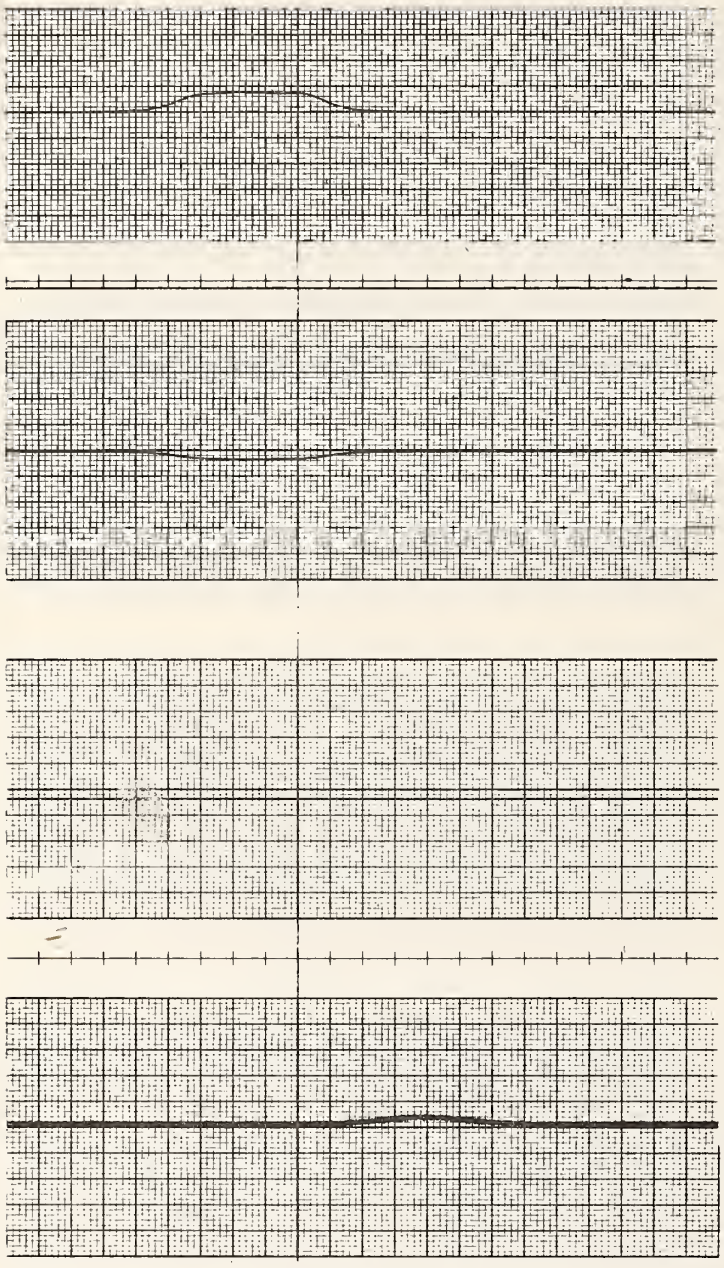
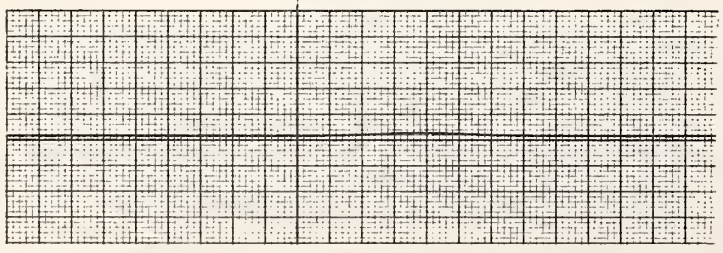


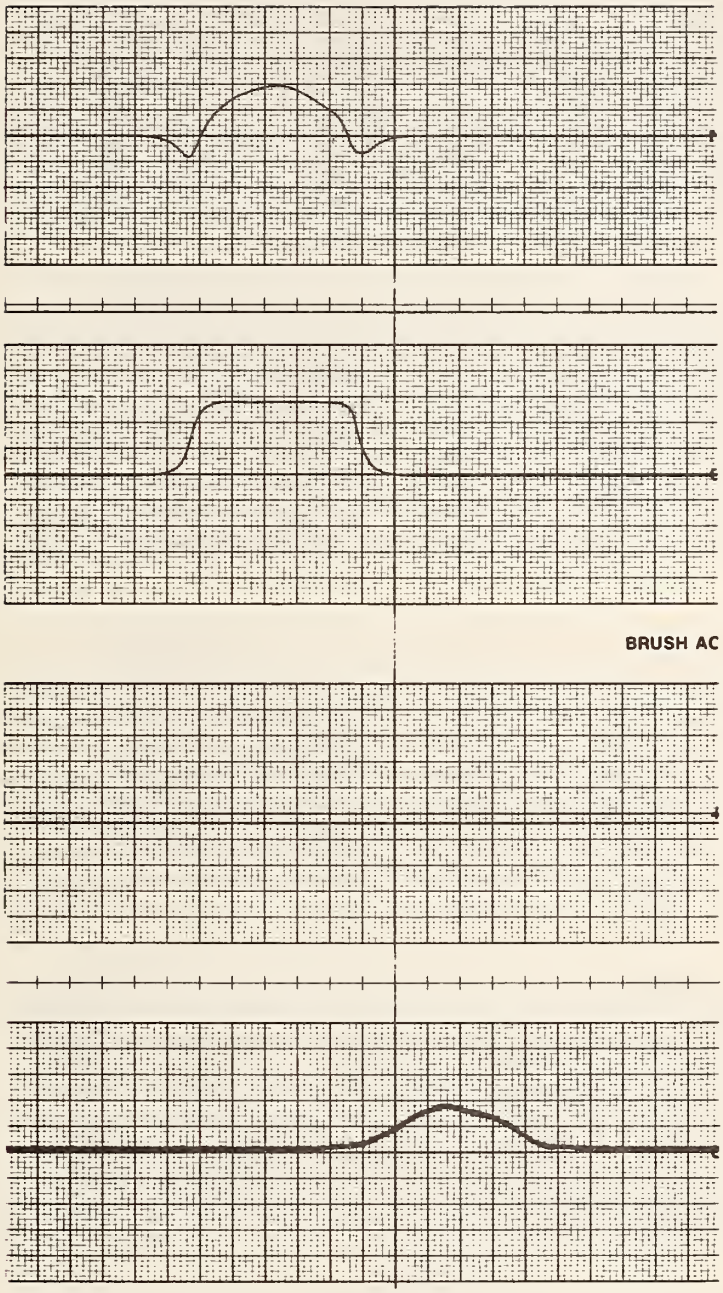
RUN 369



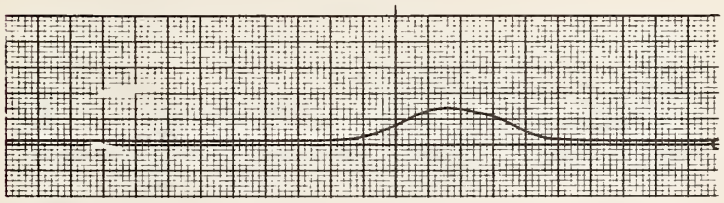


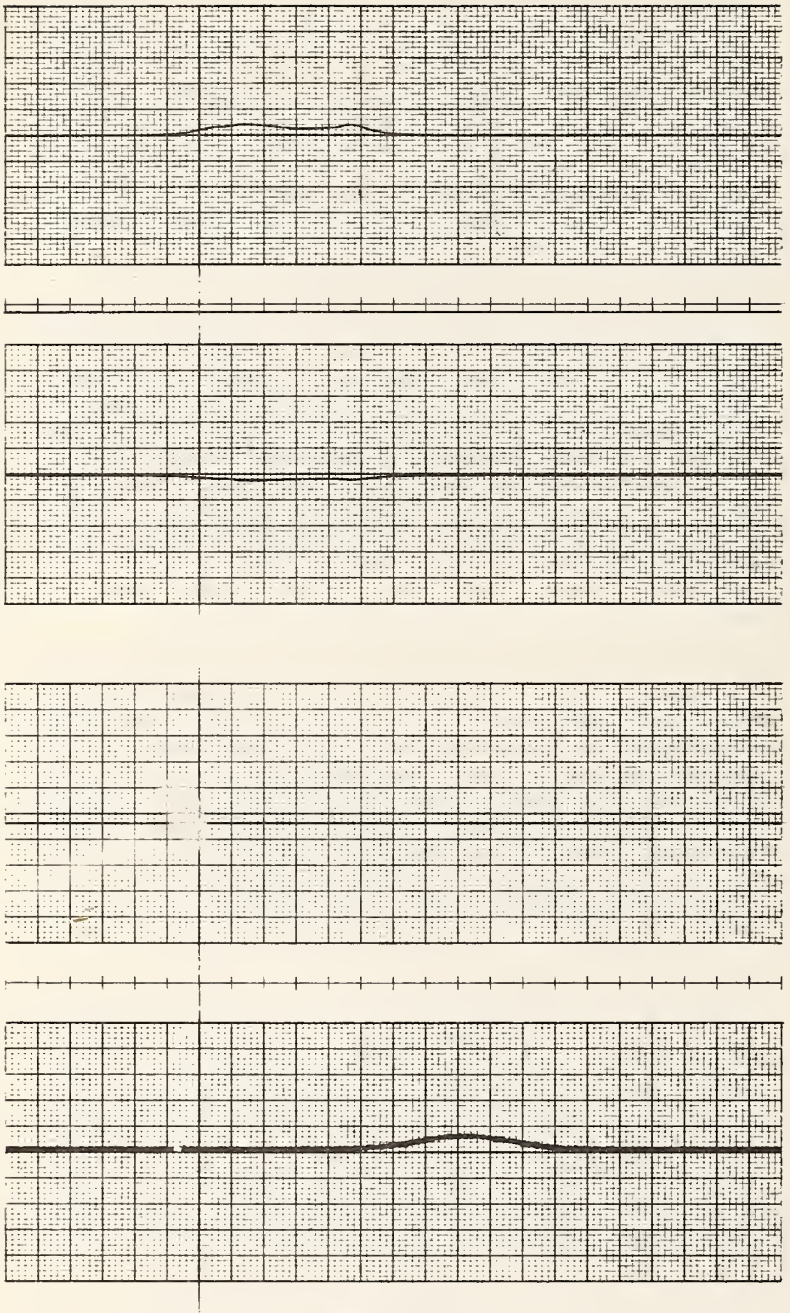
RUN 370





RUN 371





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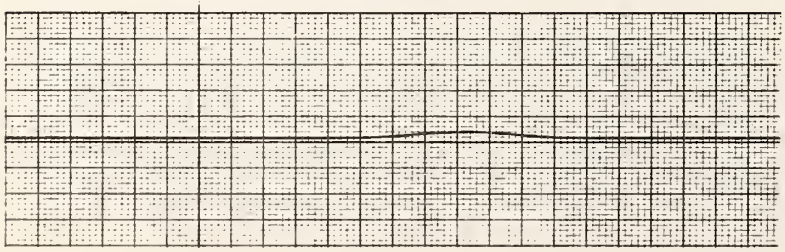
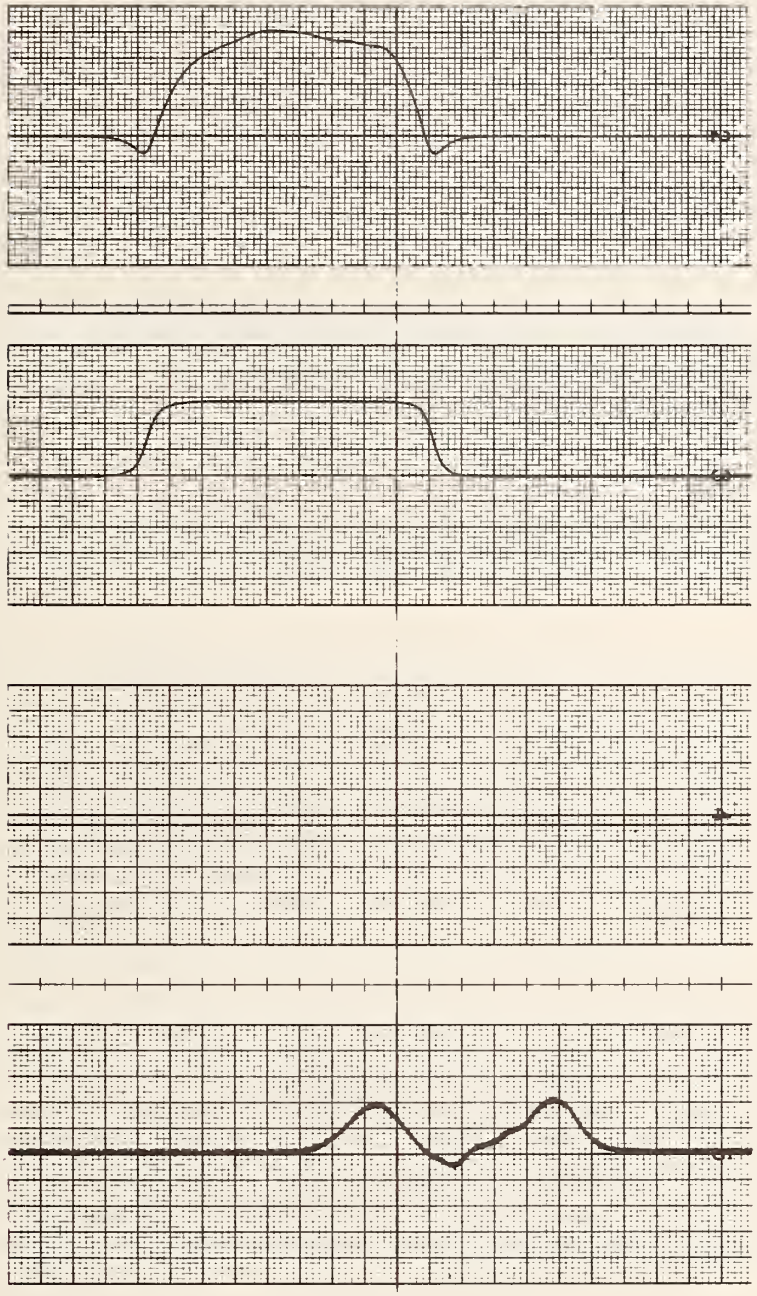
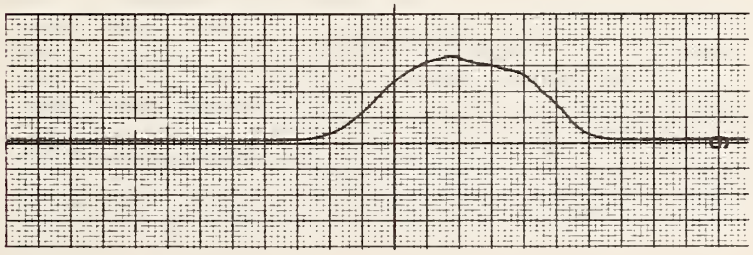
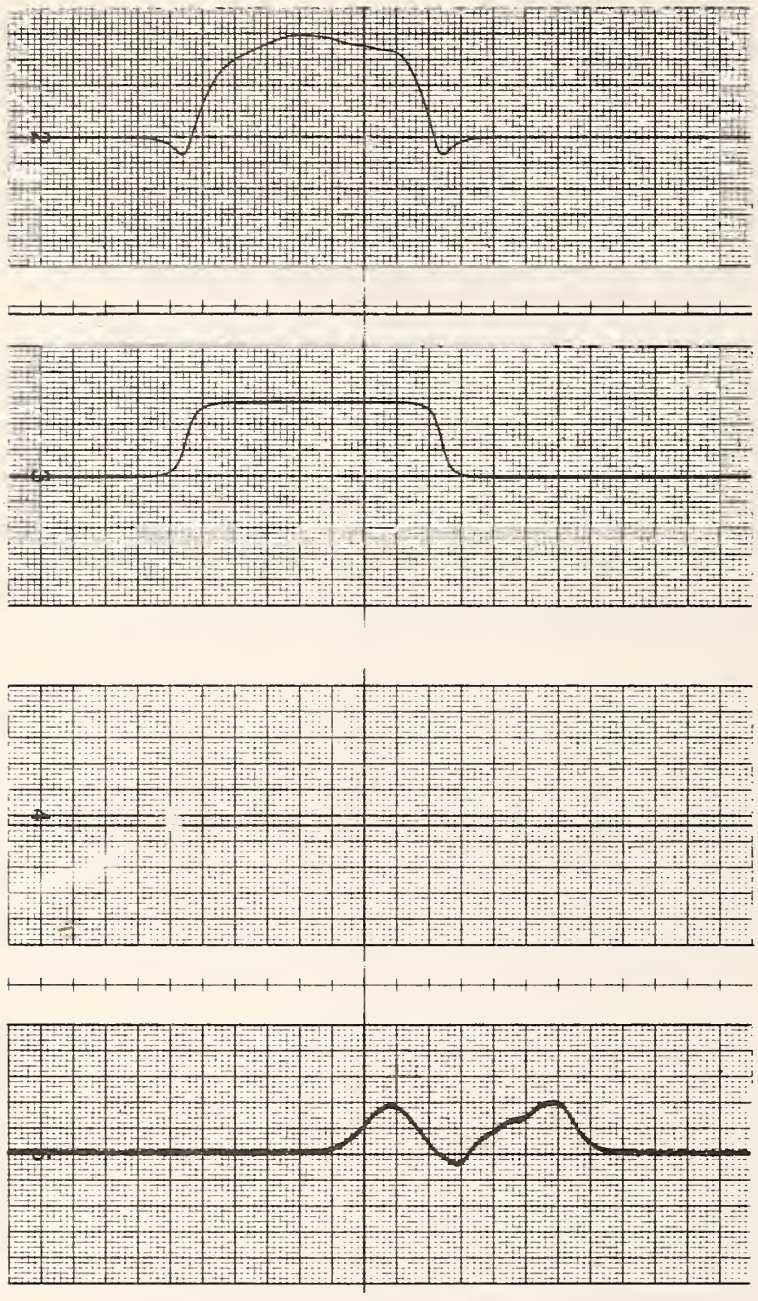


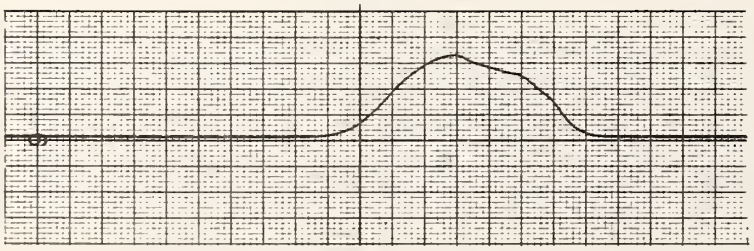


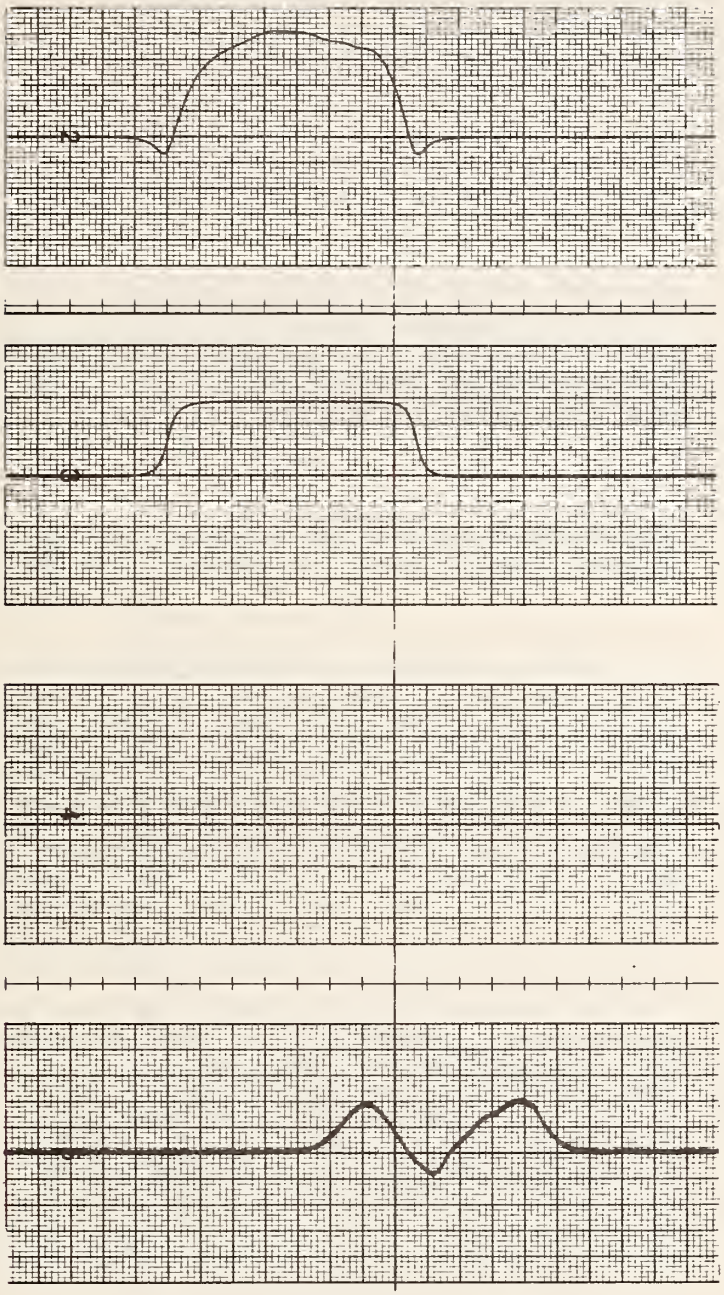
RUN 373



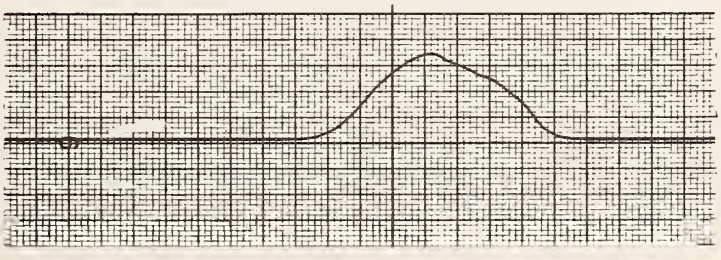


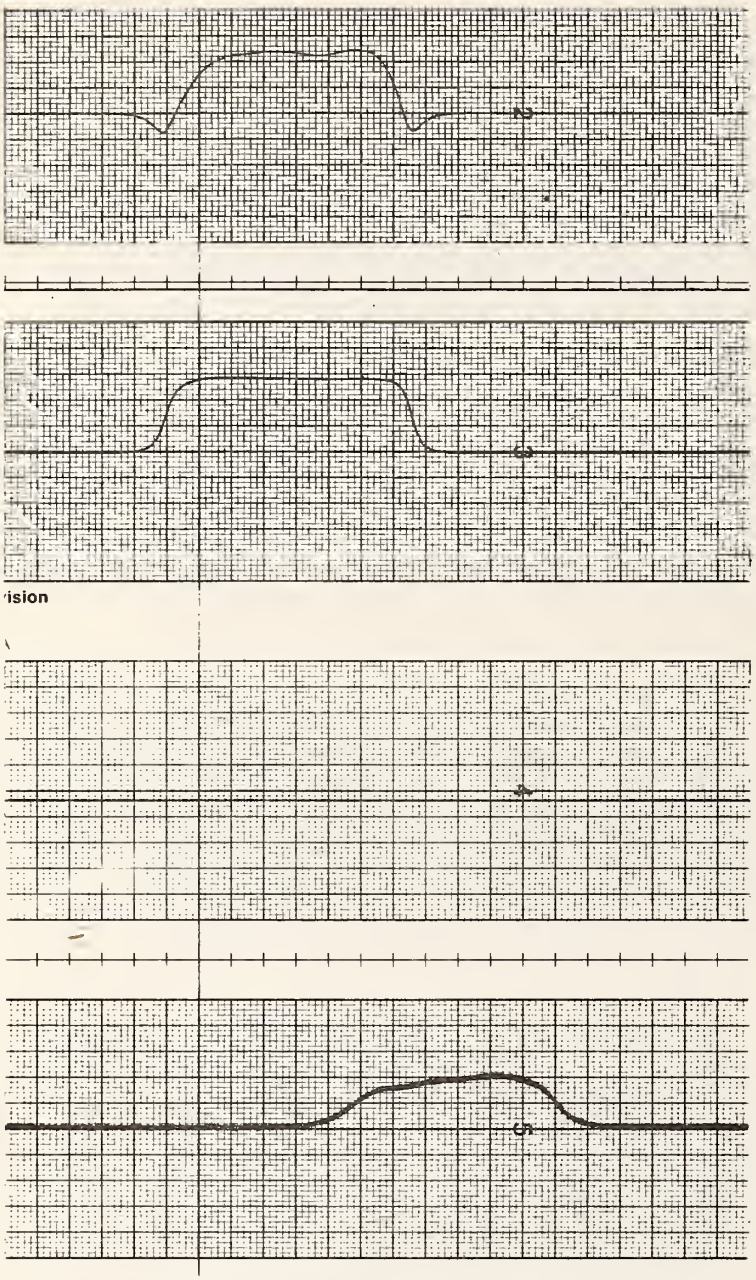
RUN 374



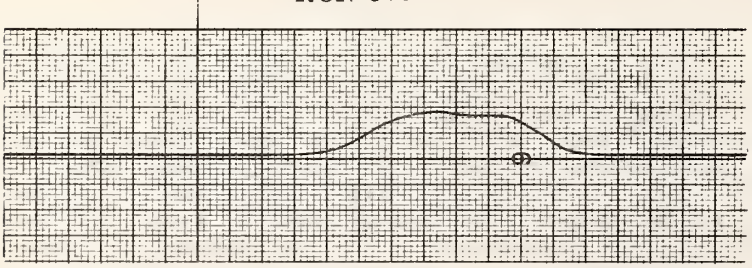


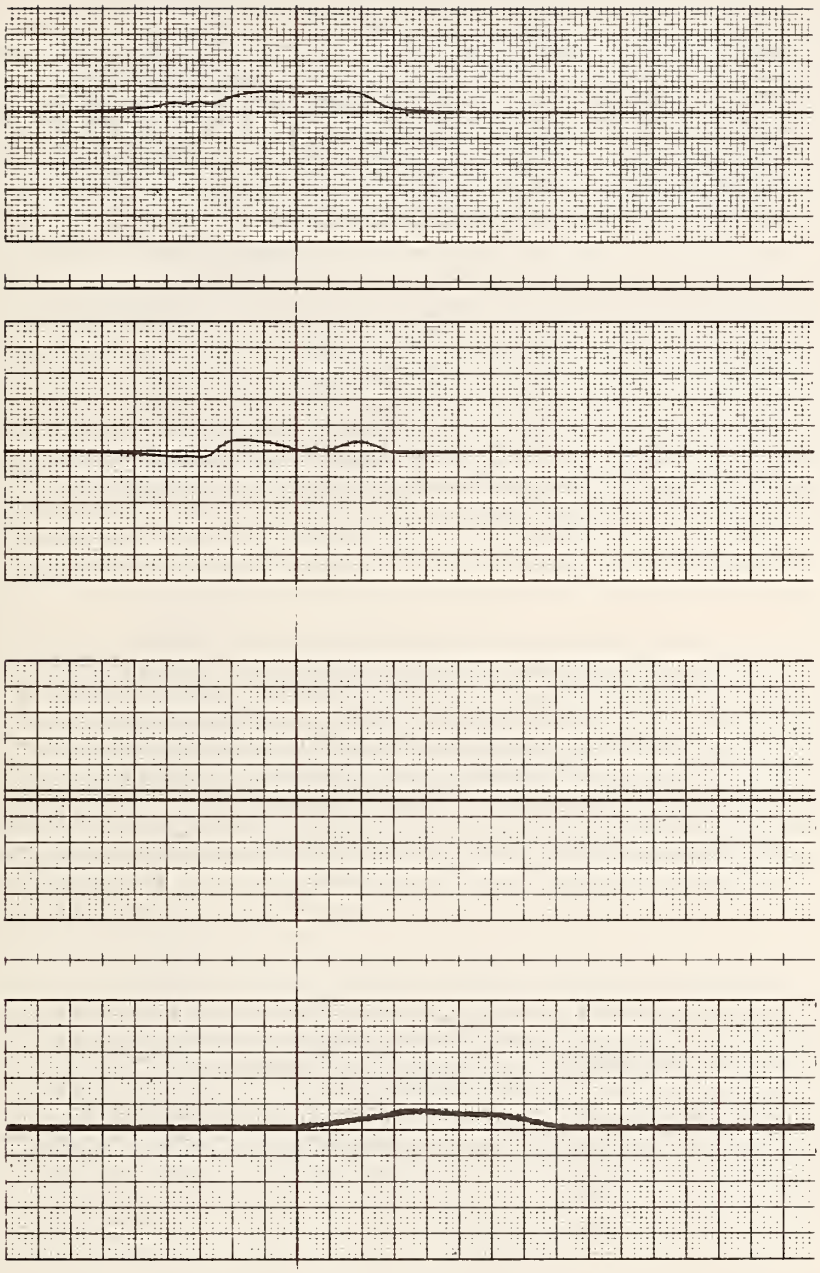
RUN 375





RUN 376





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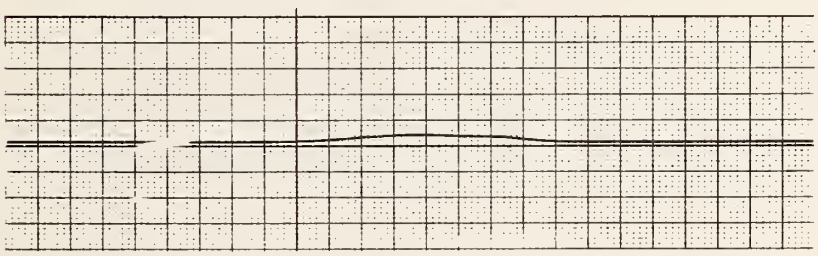

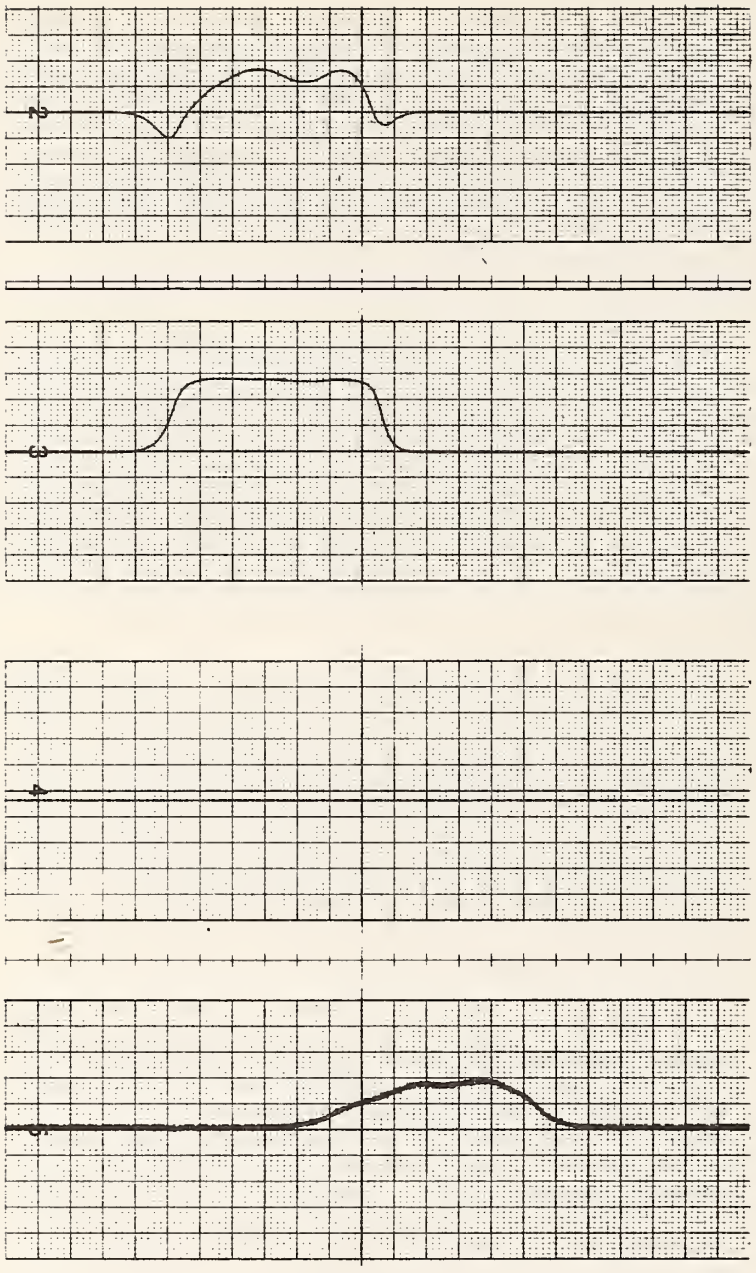

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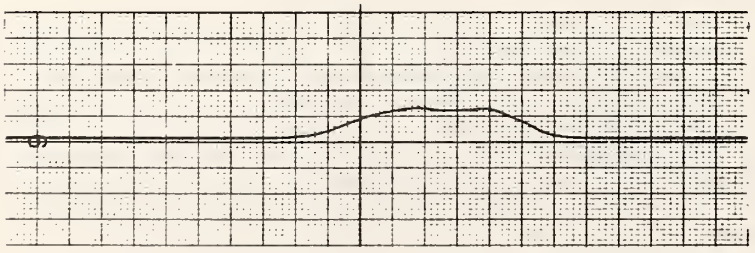

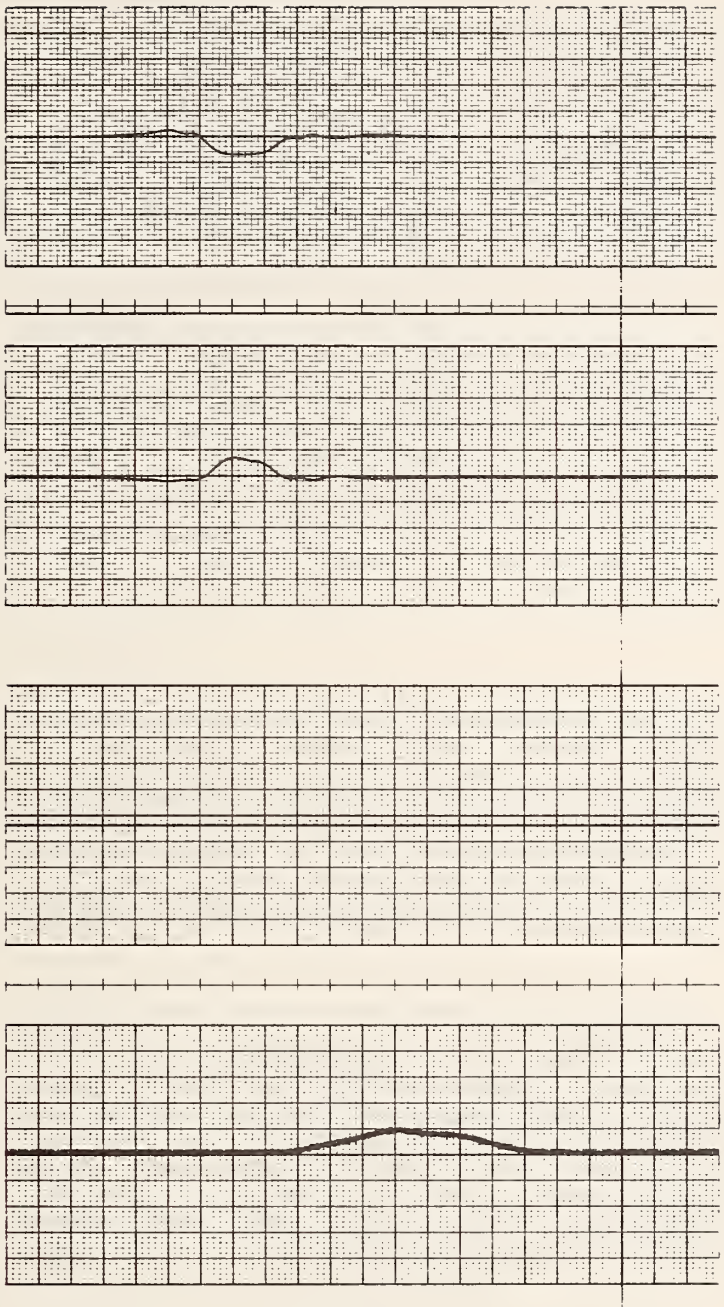

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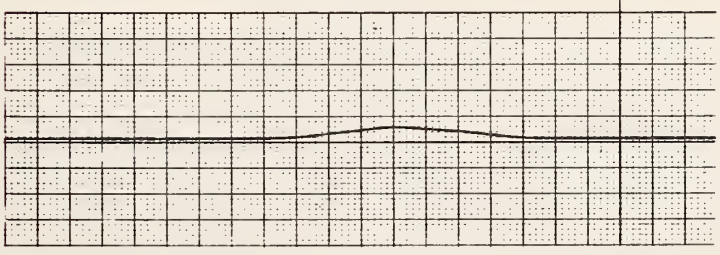

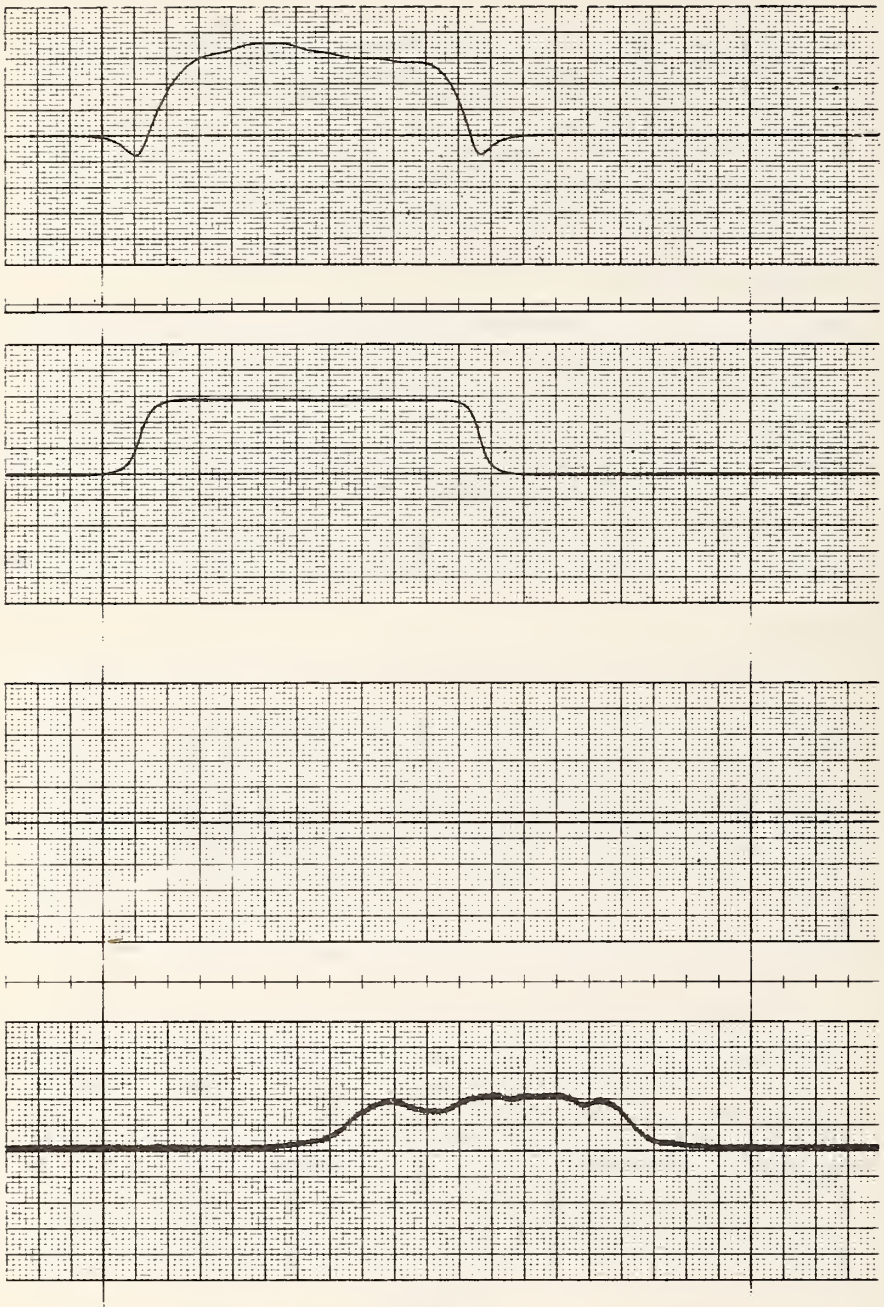

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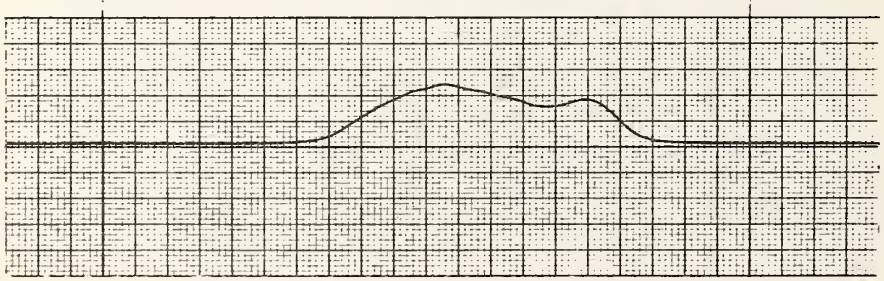

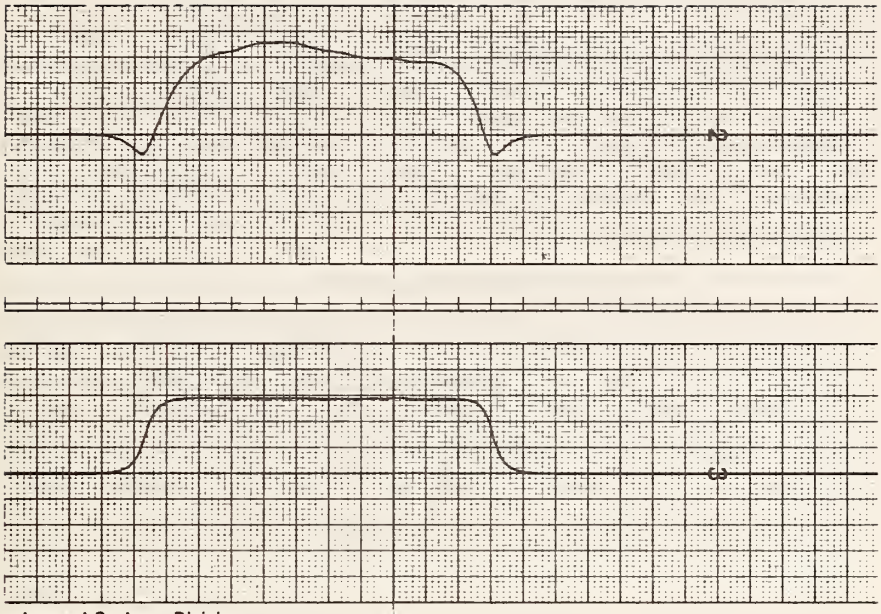

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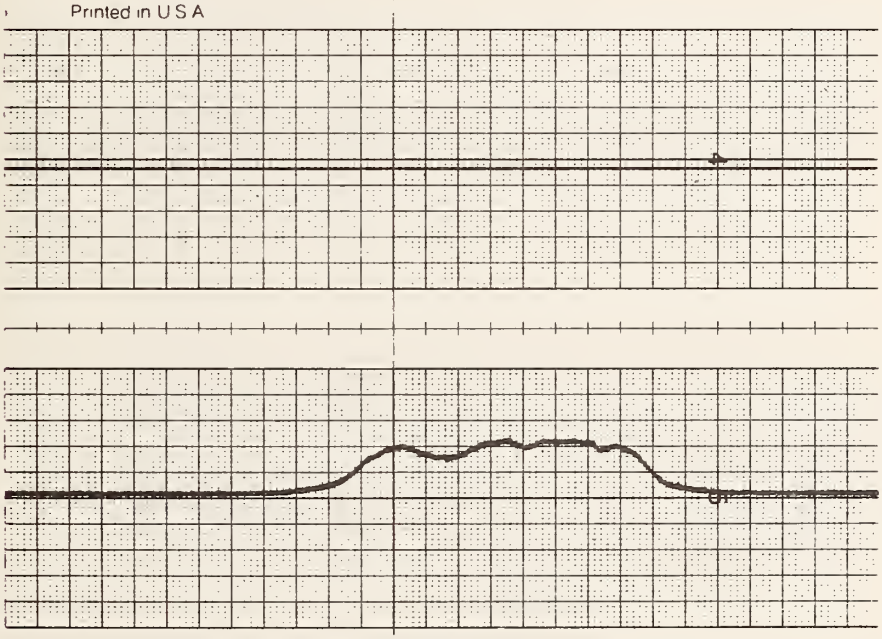

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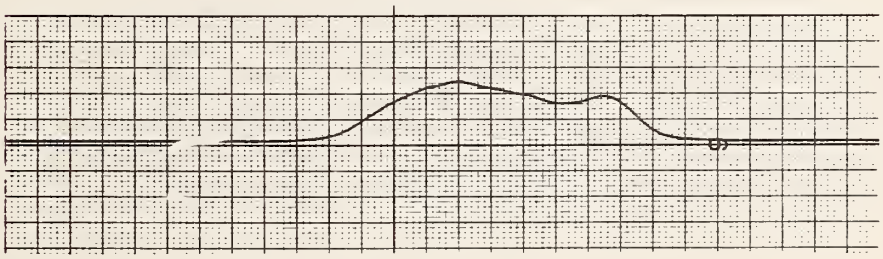

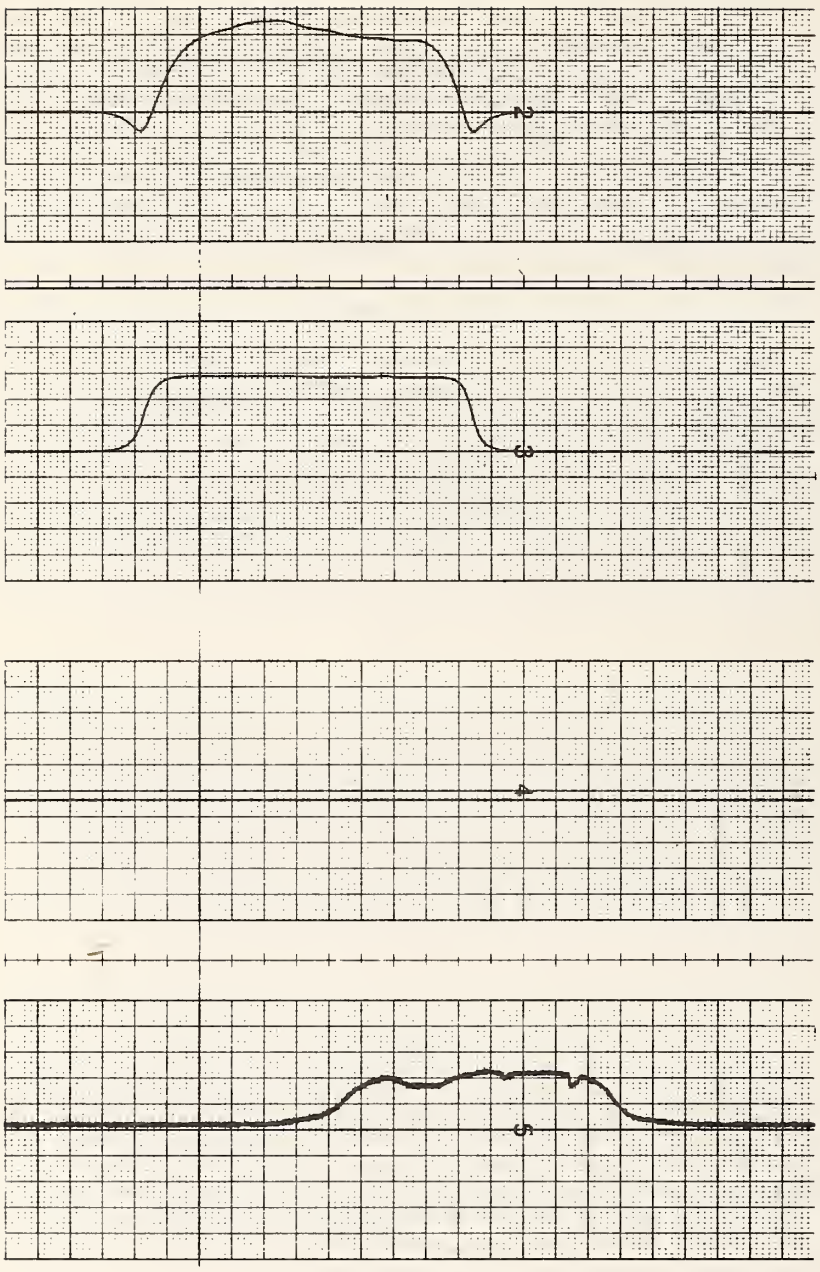

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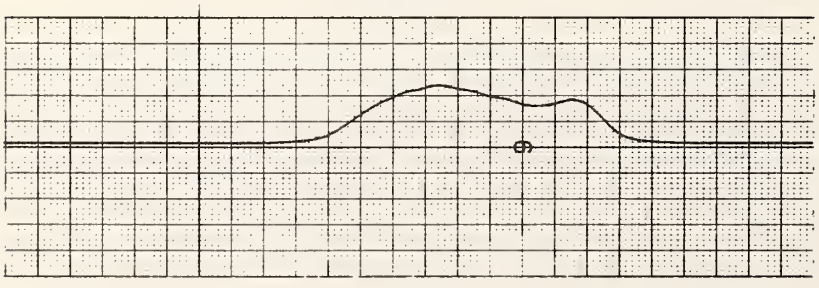

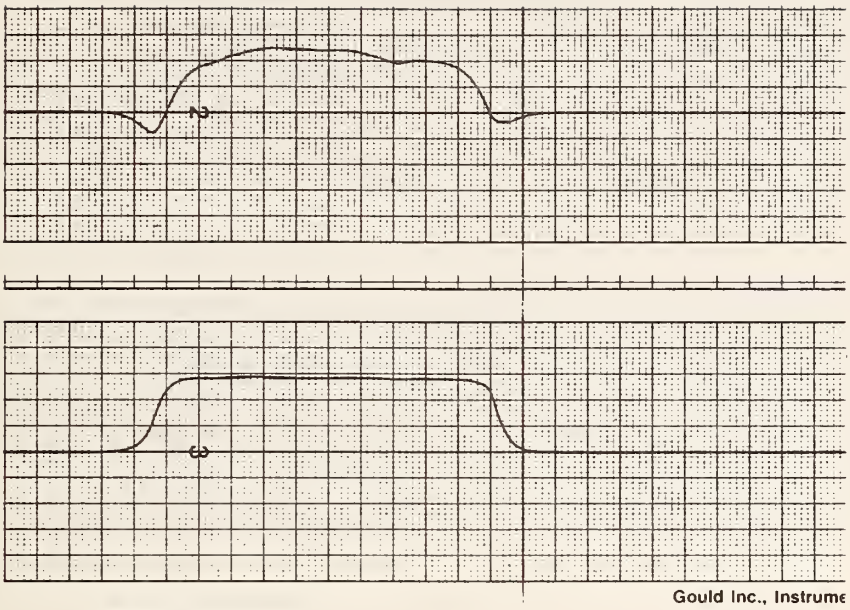

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BRUSH ACCUCHART

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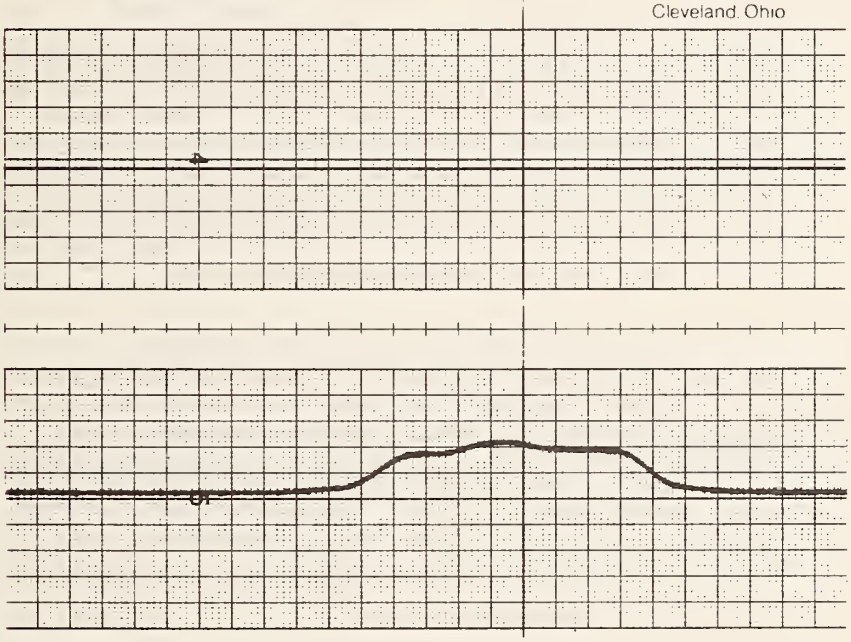

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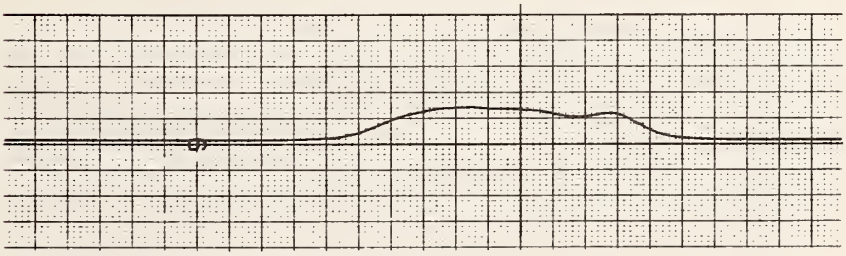

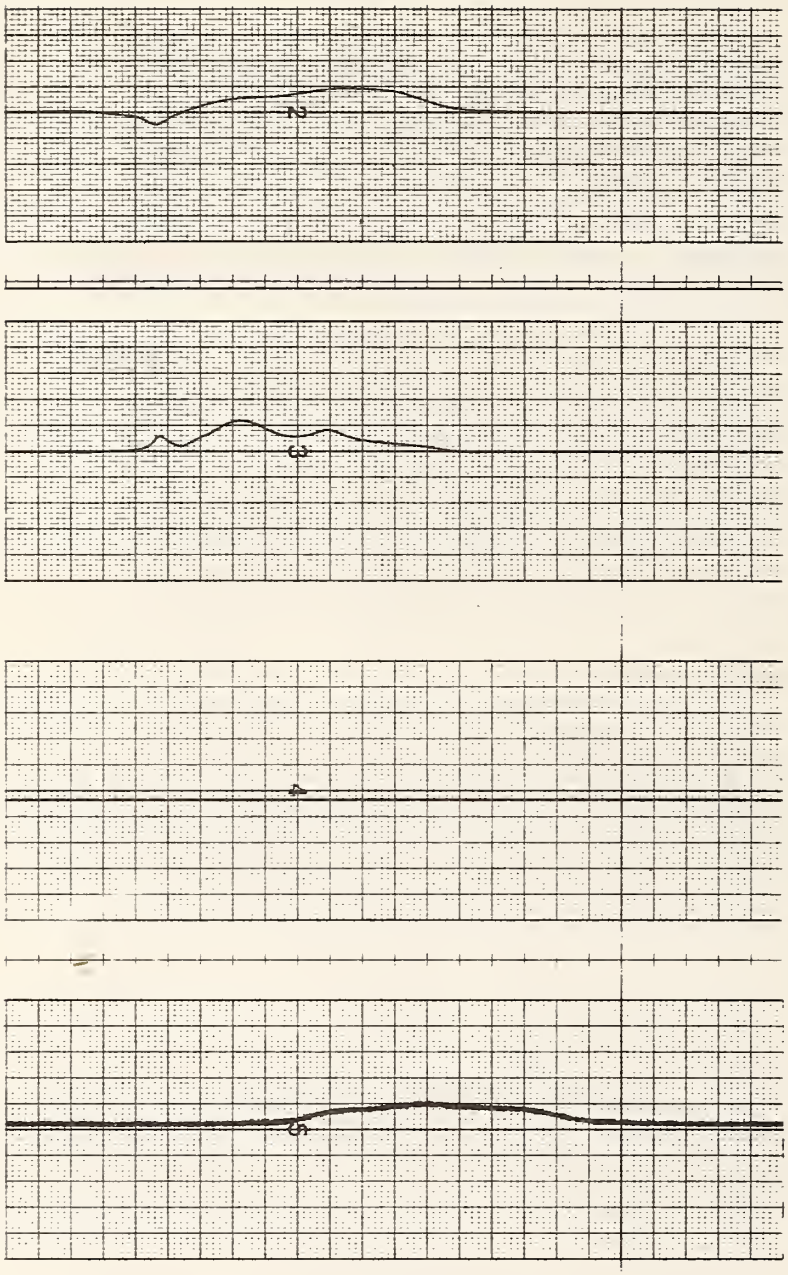

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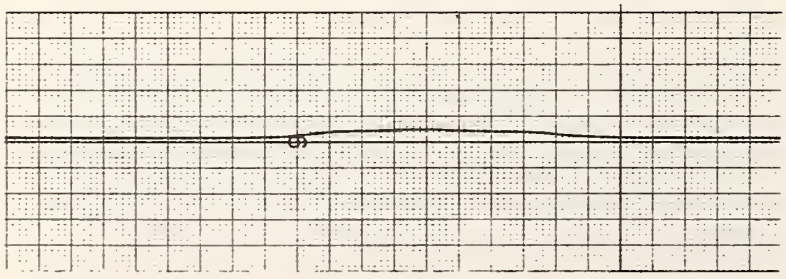

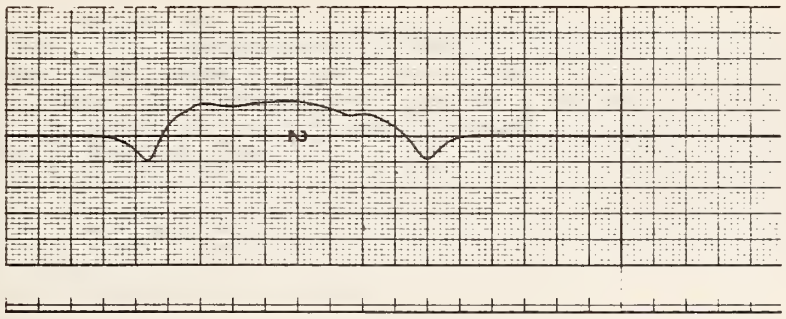

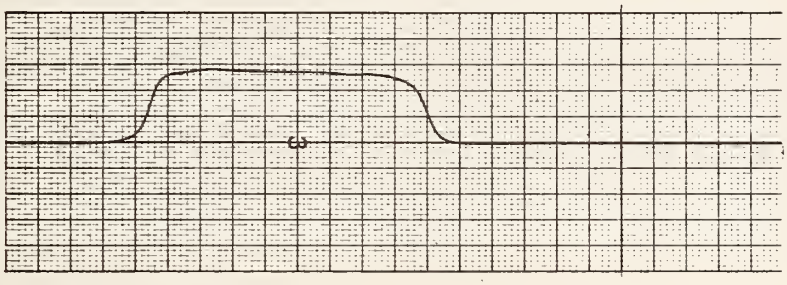

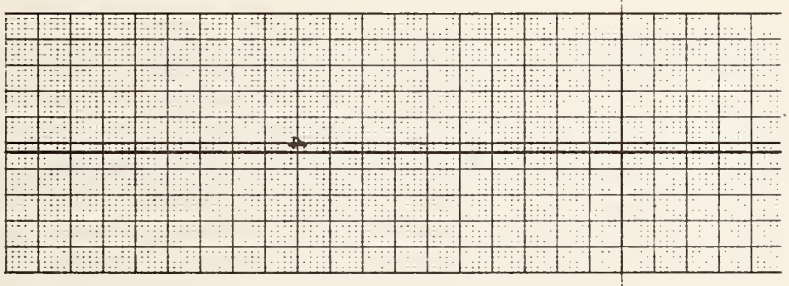

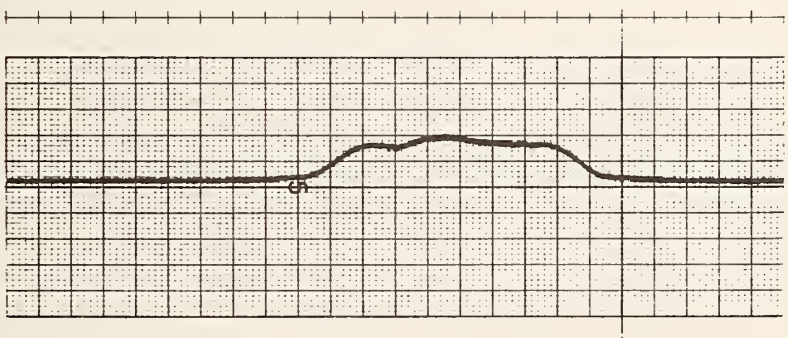

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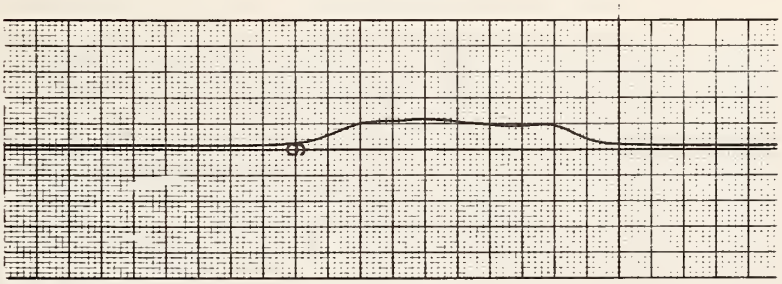

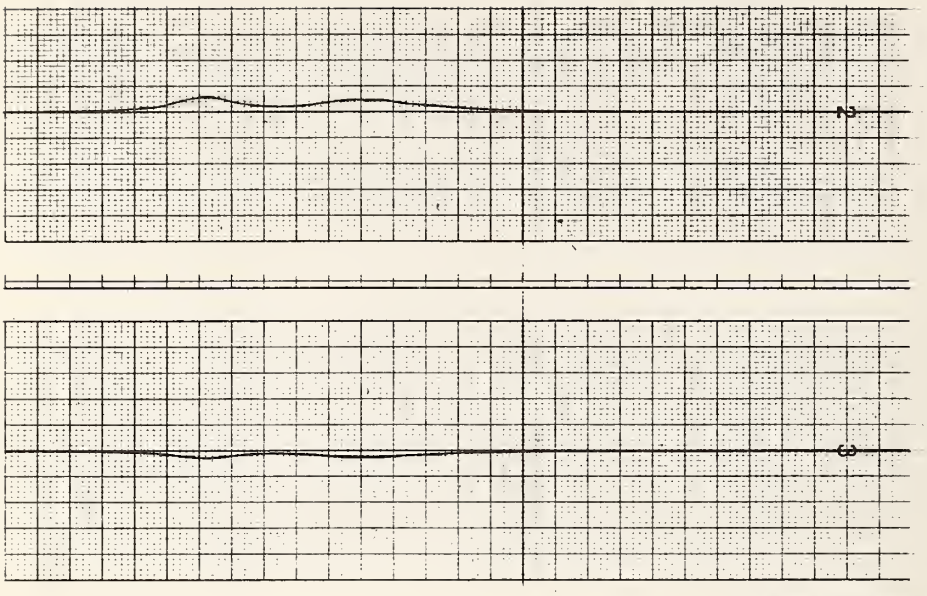

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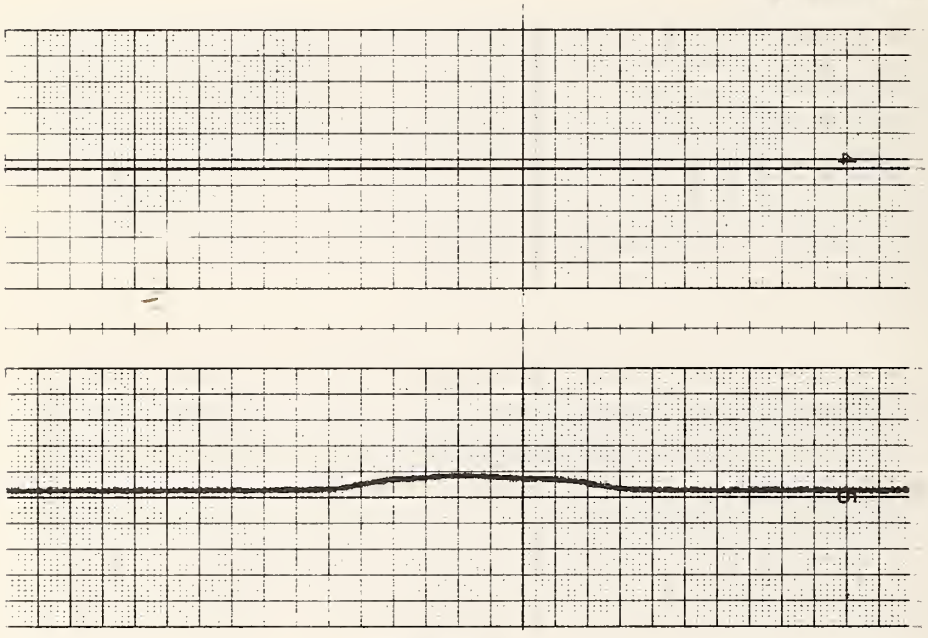

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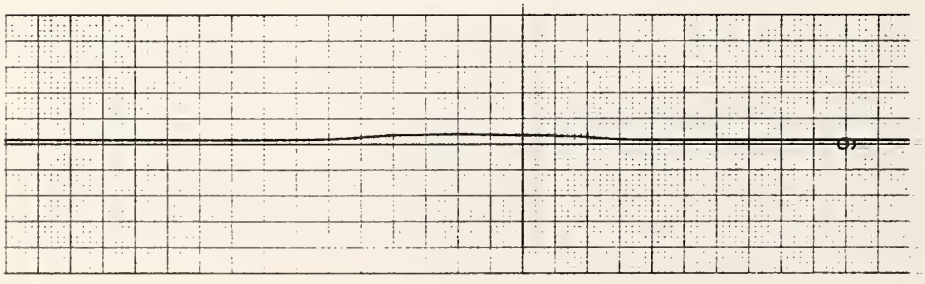

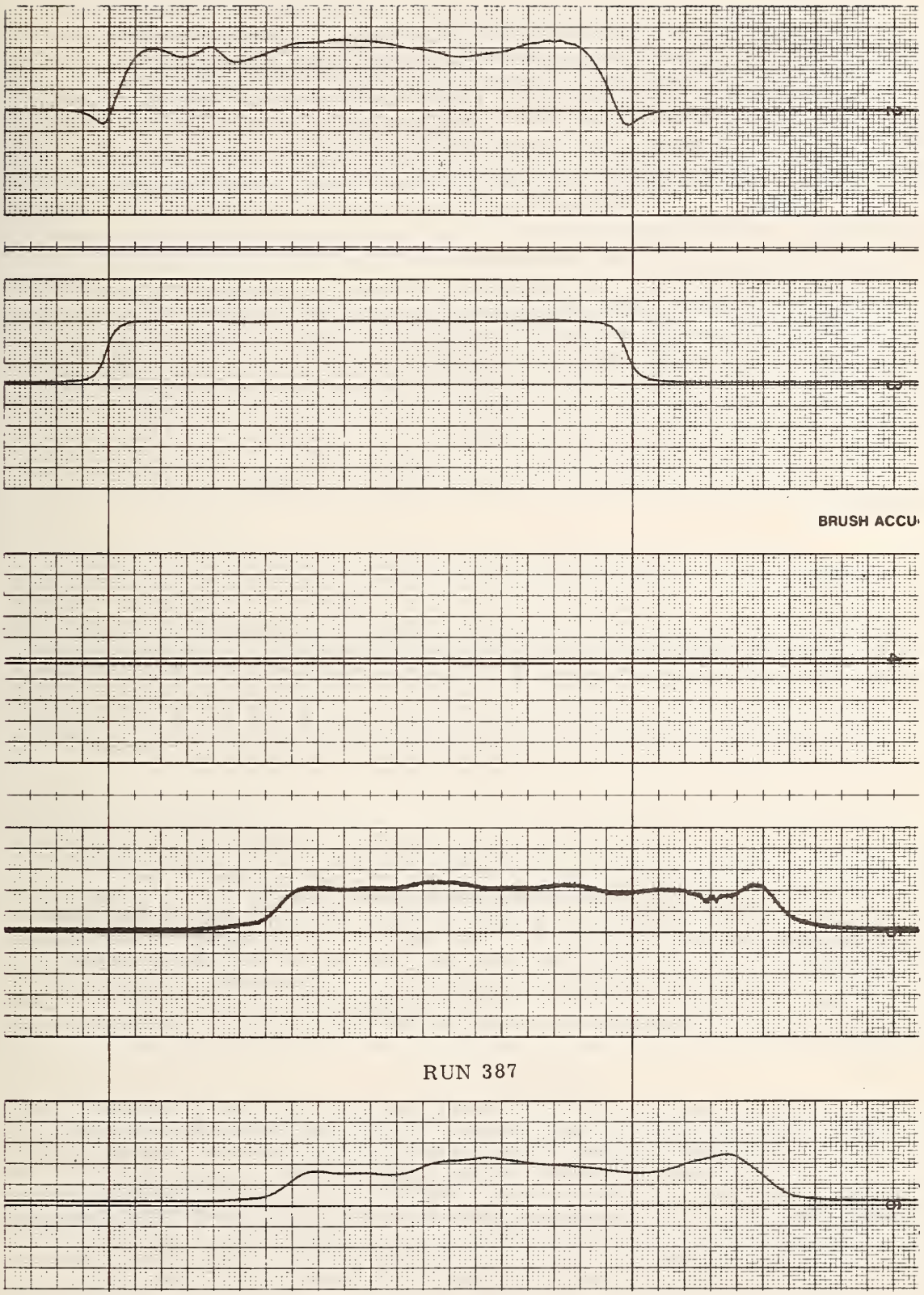

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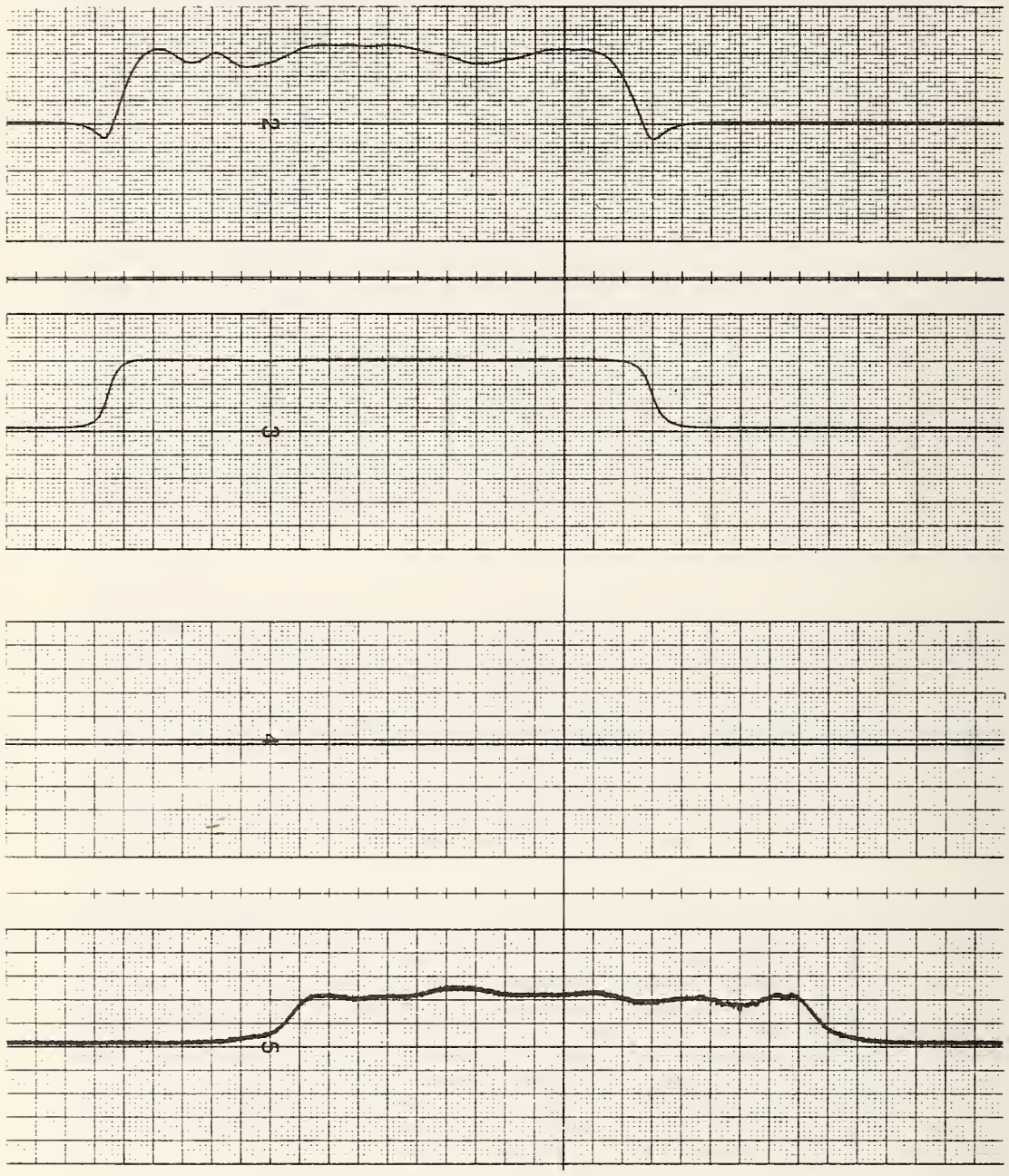

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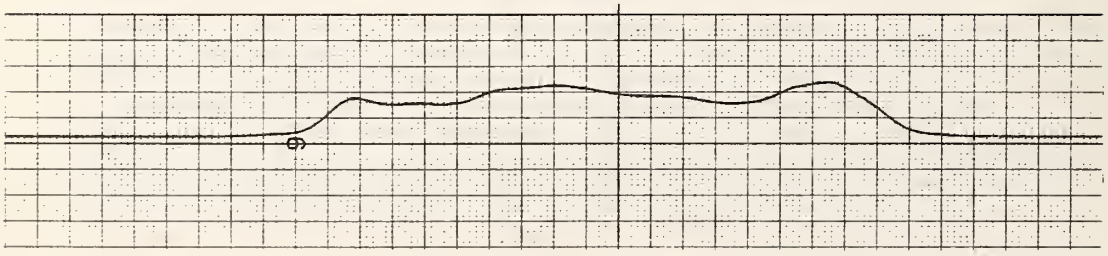

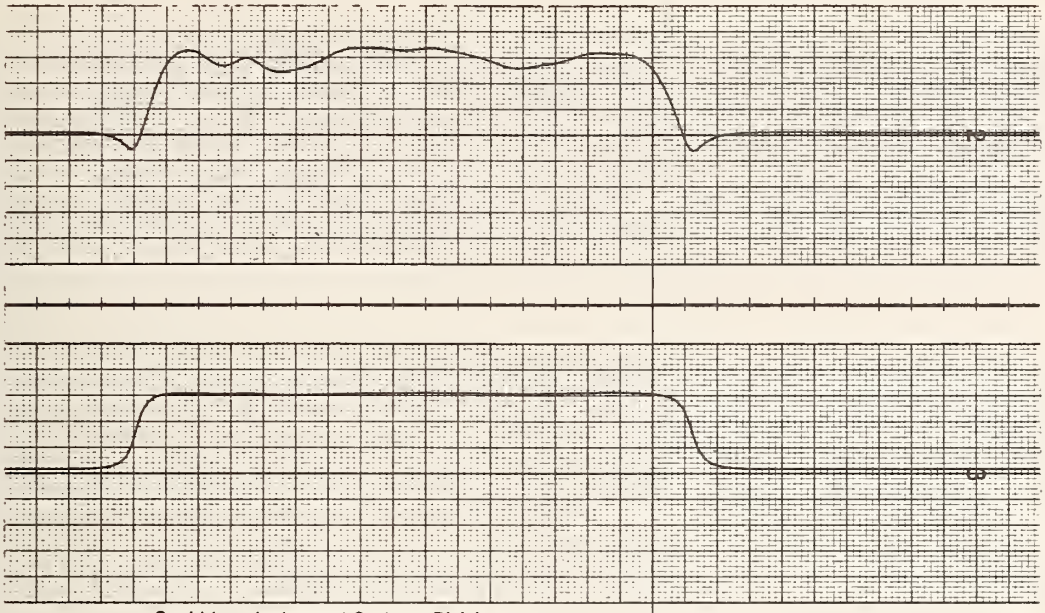

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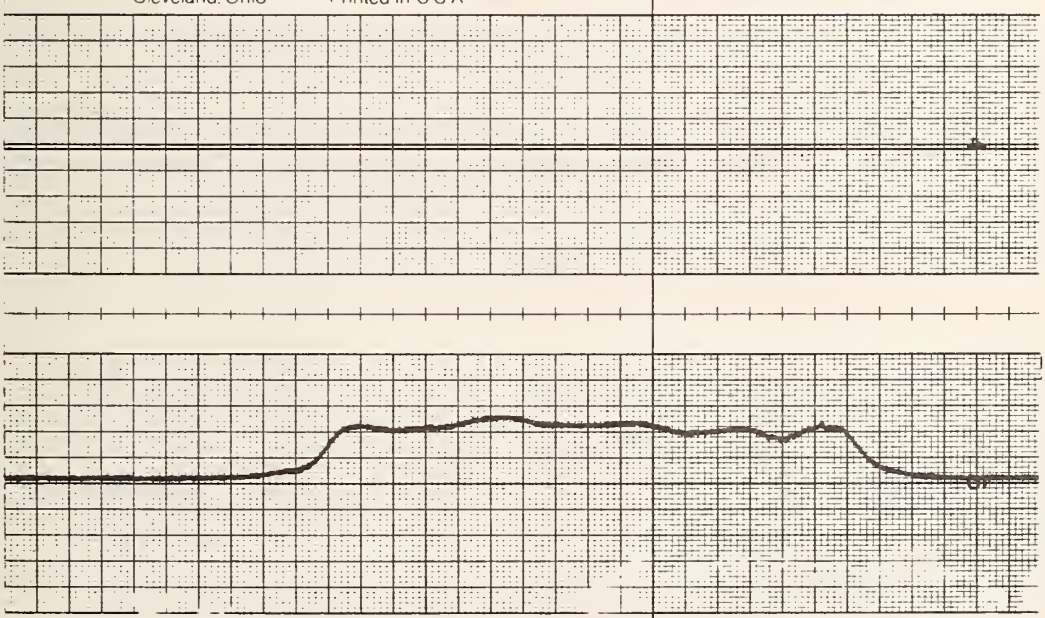

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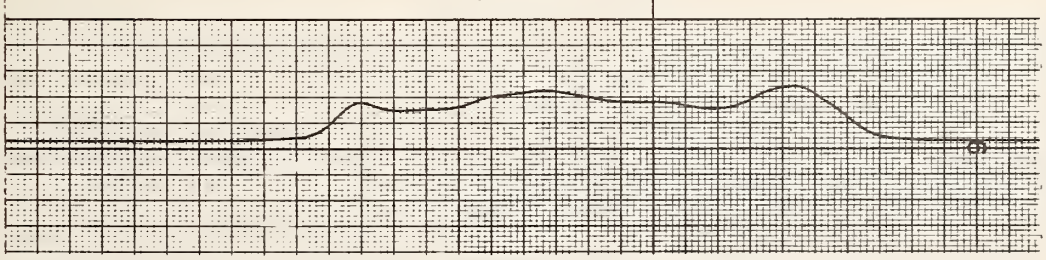

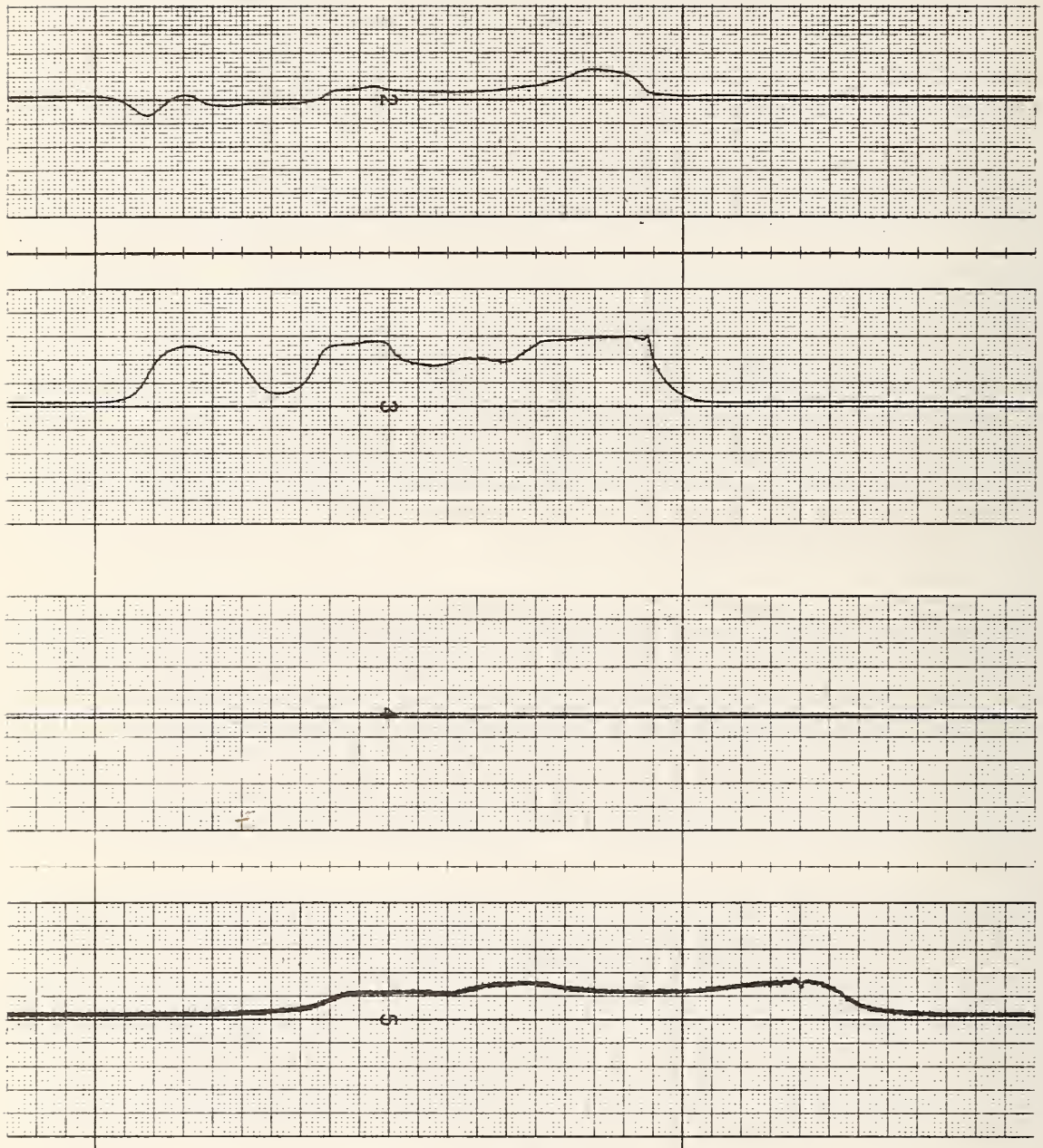

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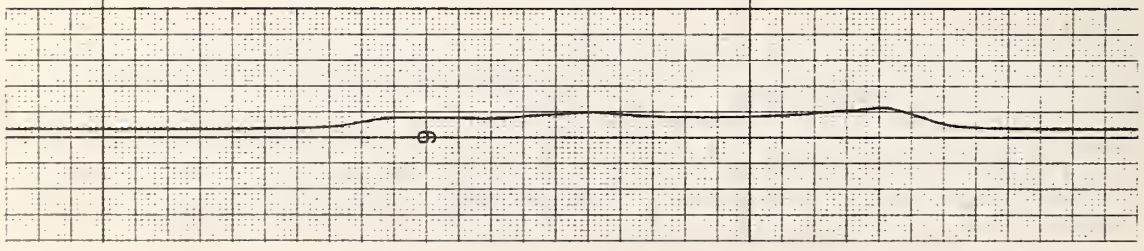

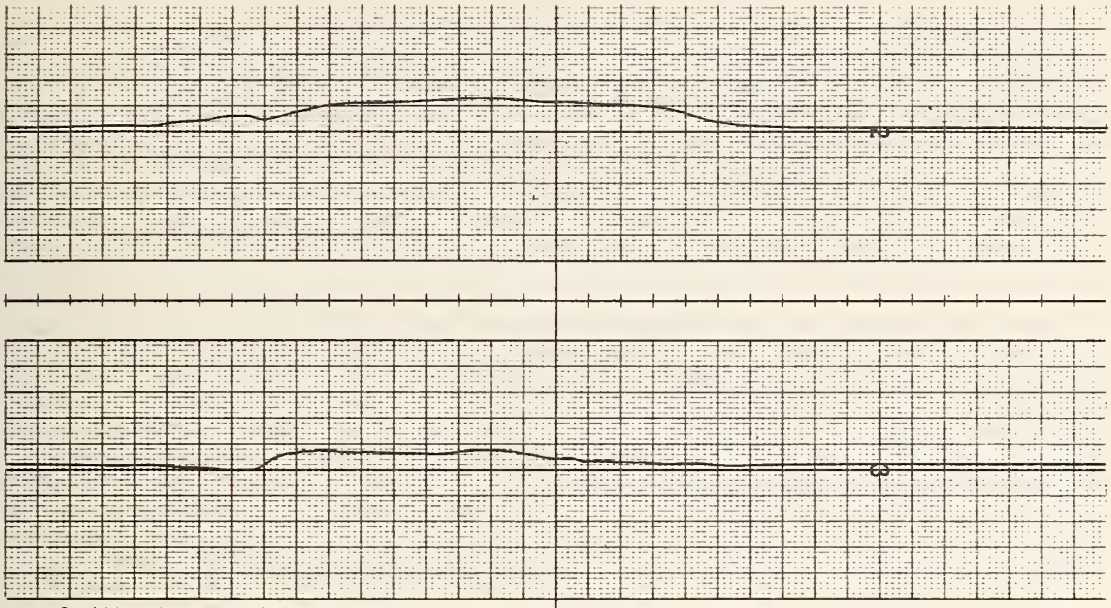

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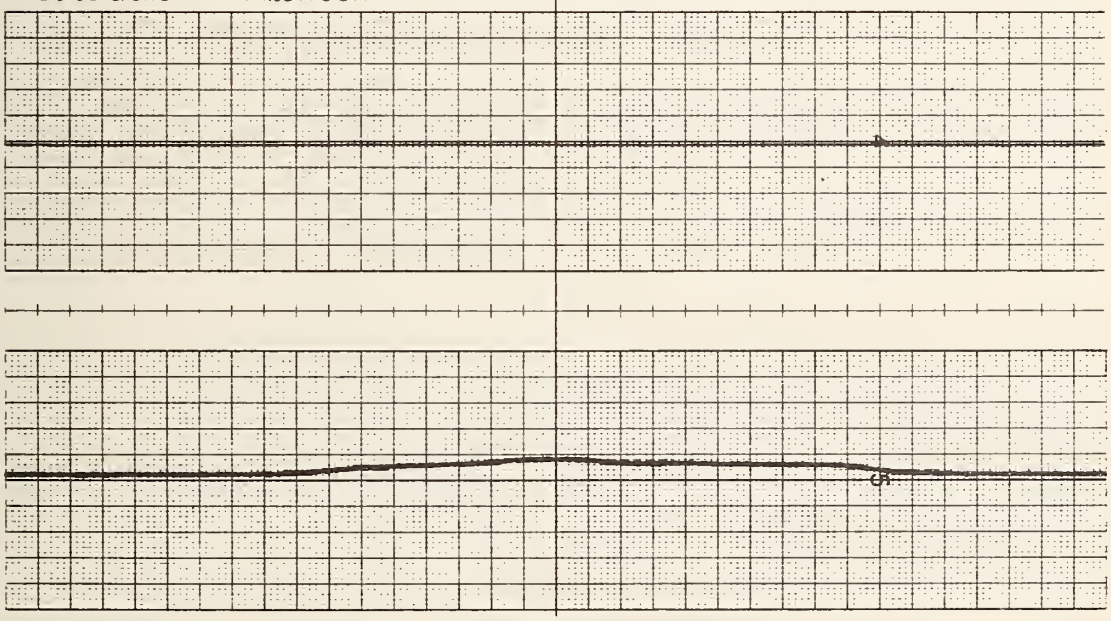

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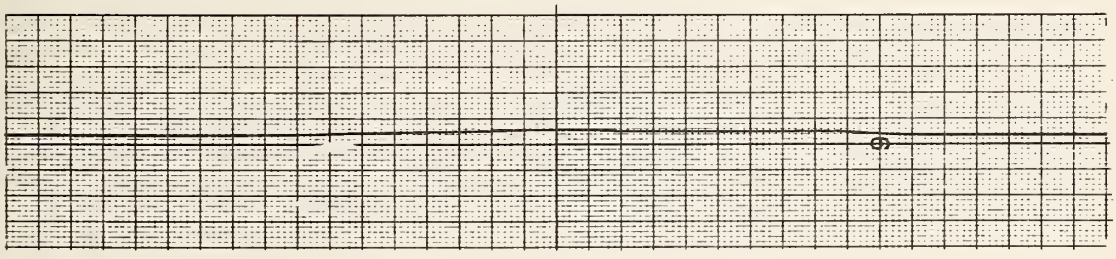

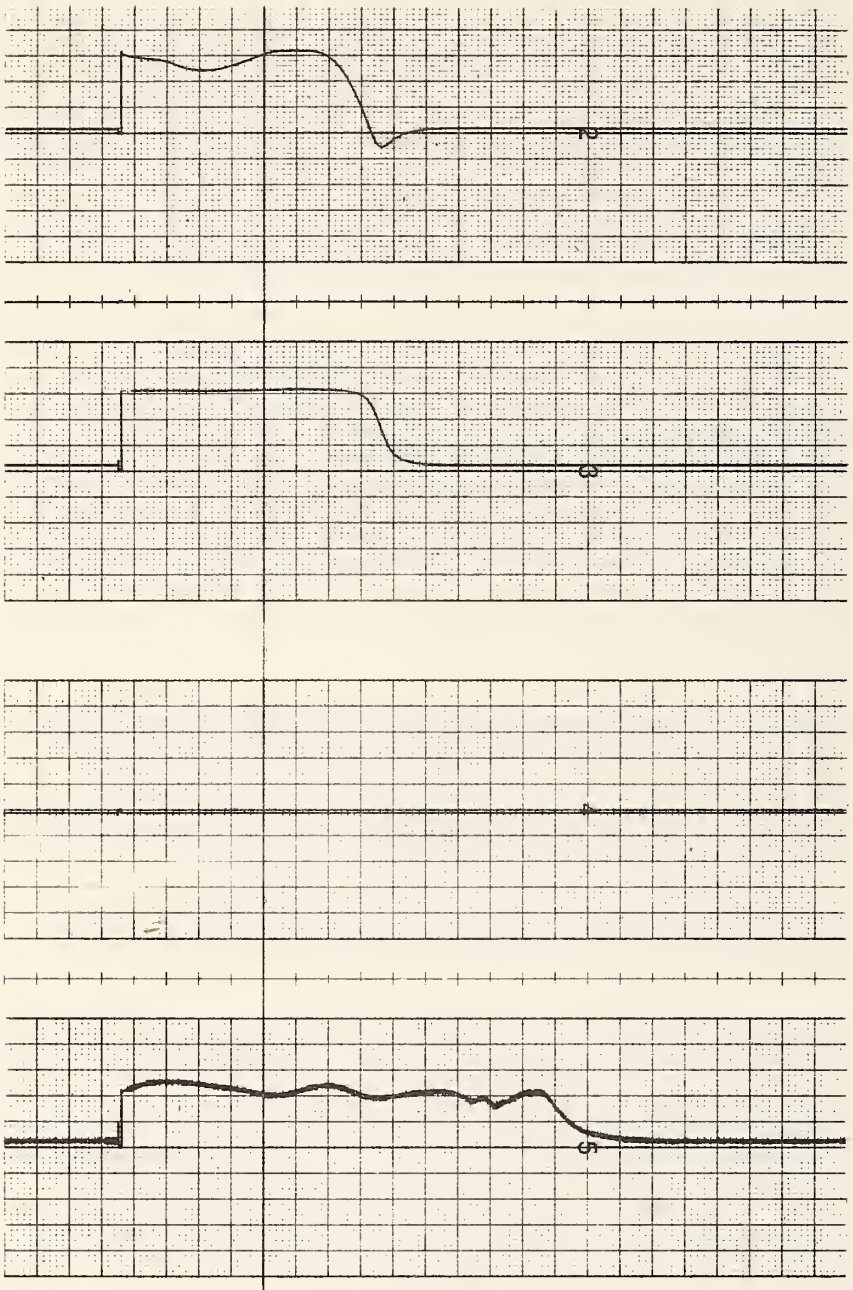

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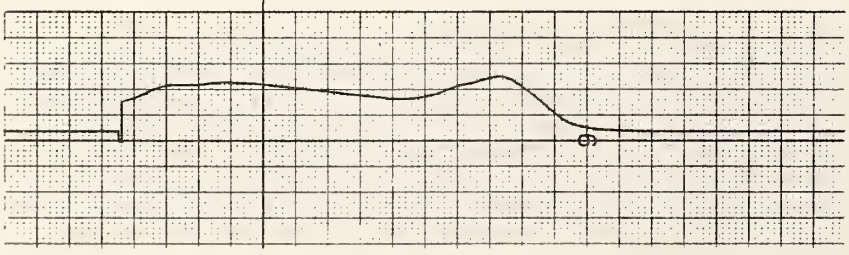
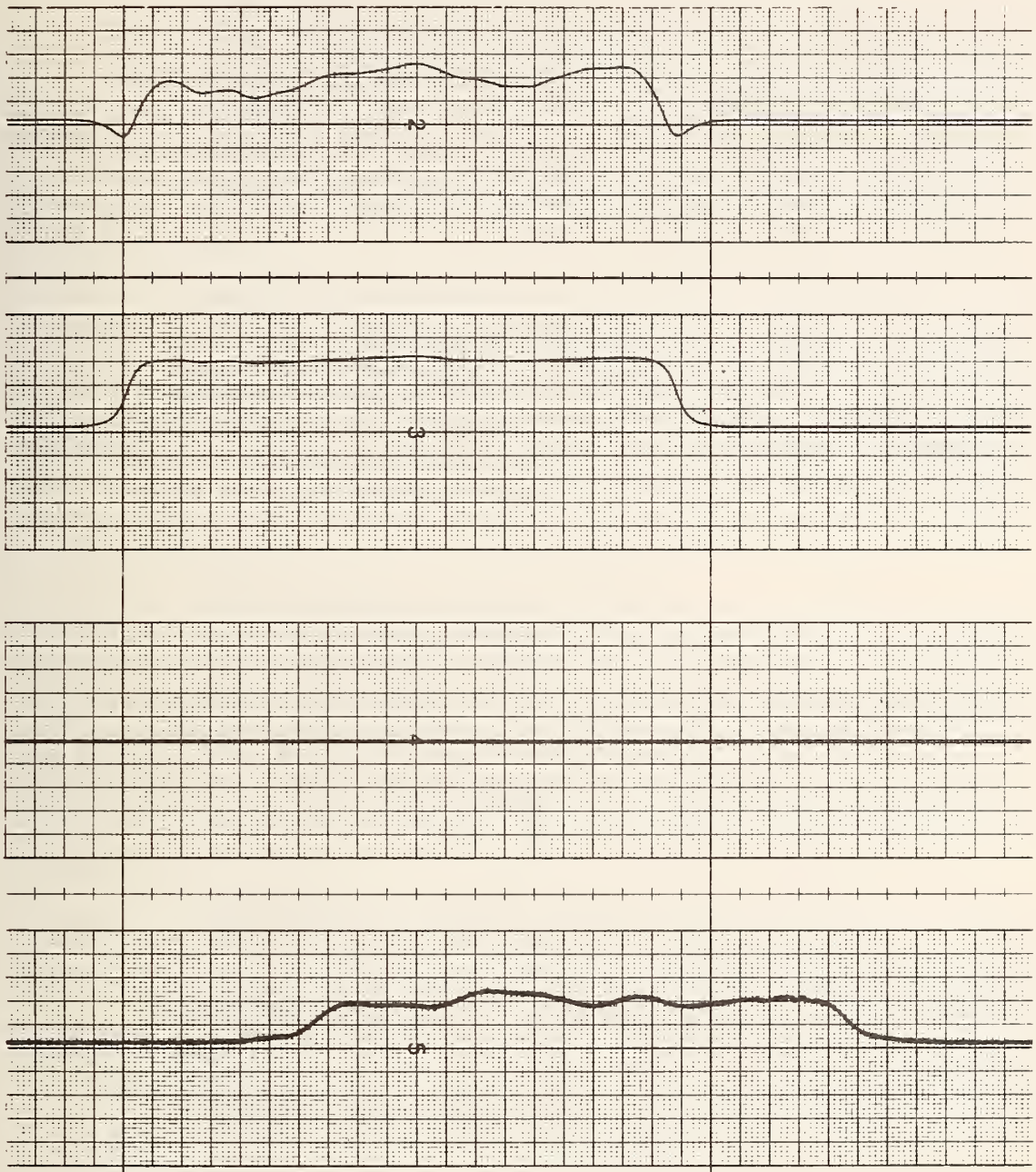
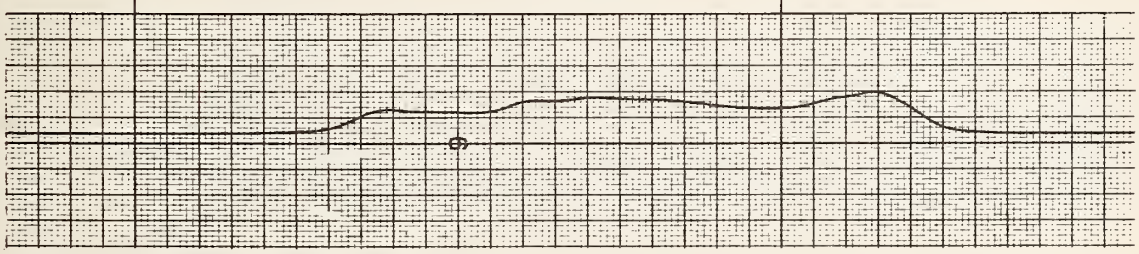
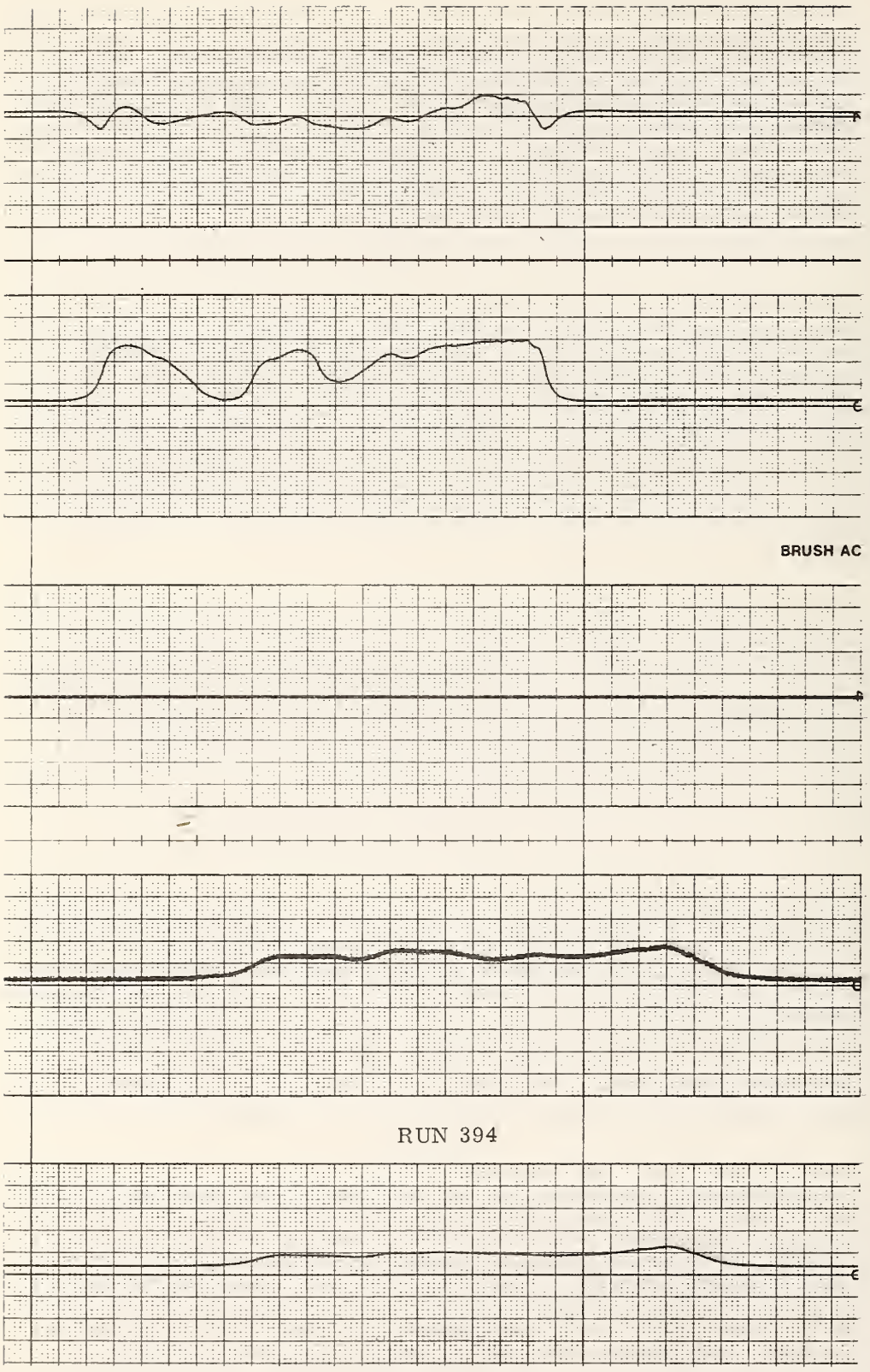




RUN 393




BRUSH AC
RUN 394

Runs 395-440

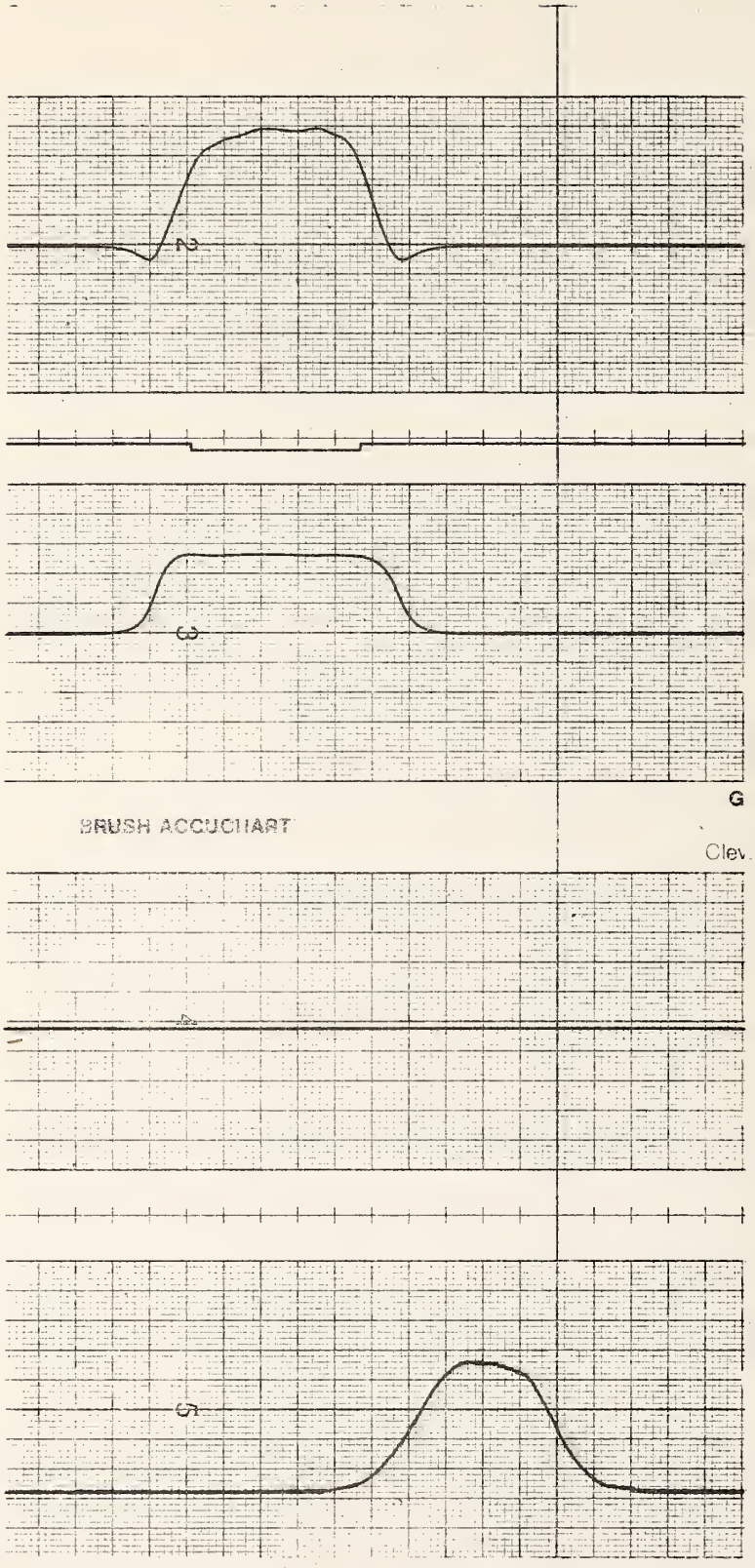
From top to bottom:

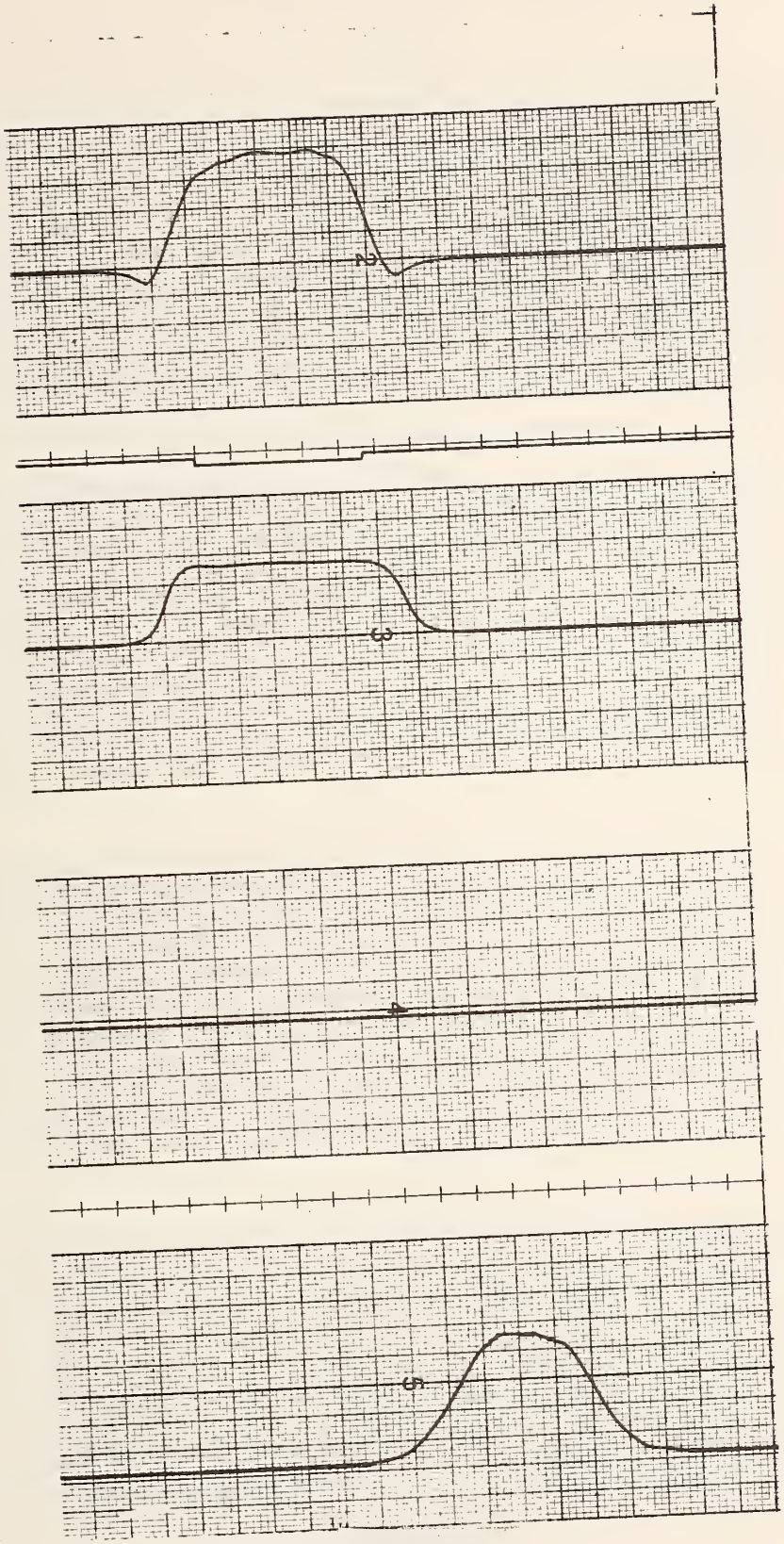
Trace 1 = MGVD amplitude

Trace 2 = MGVD phase

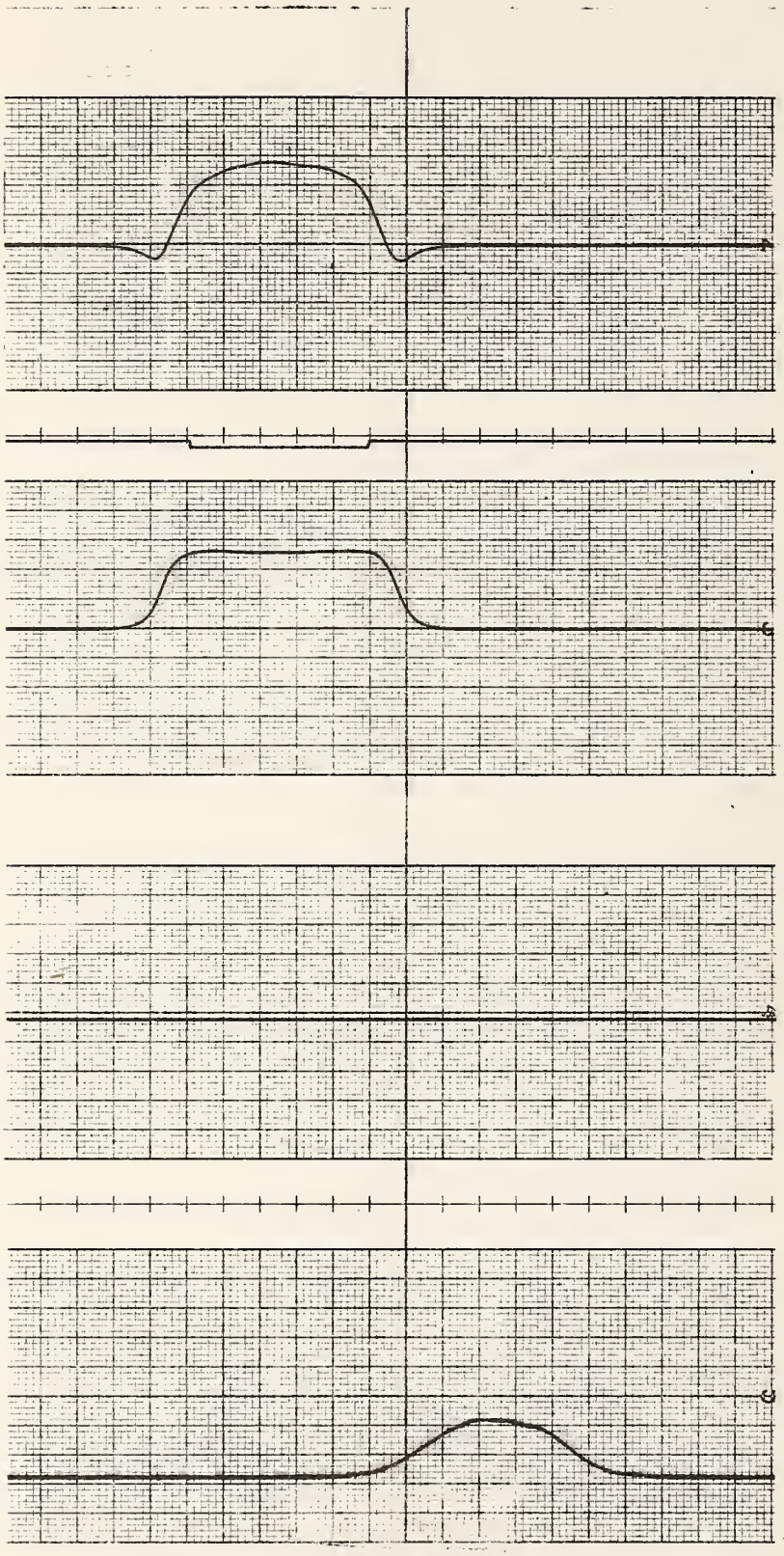
Trace 3 = N/A

Trace 4 = ILD FM

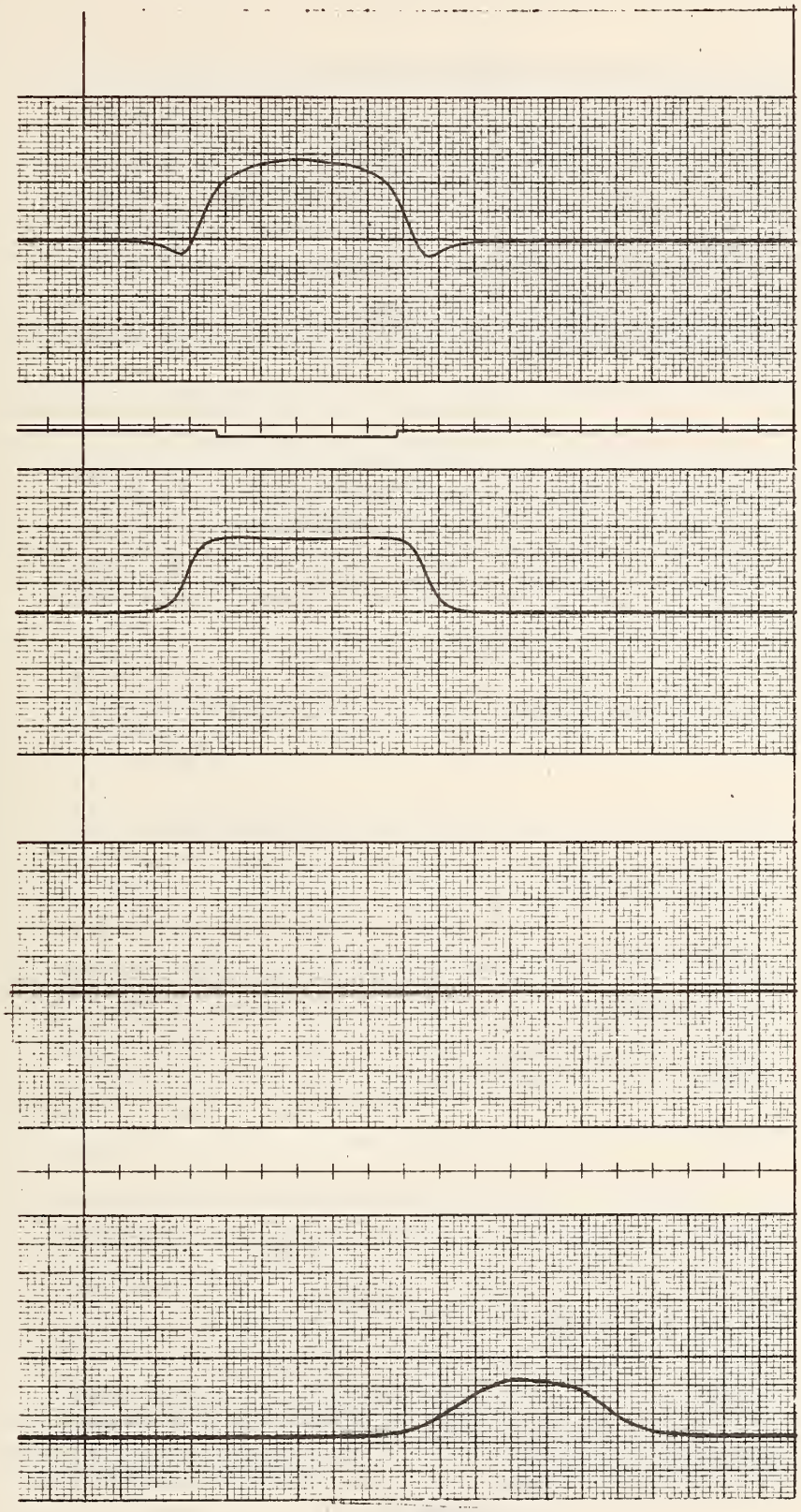

BRUSH ACCUCHART
Clev
G
RUN 395



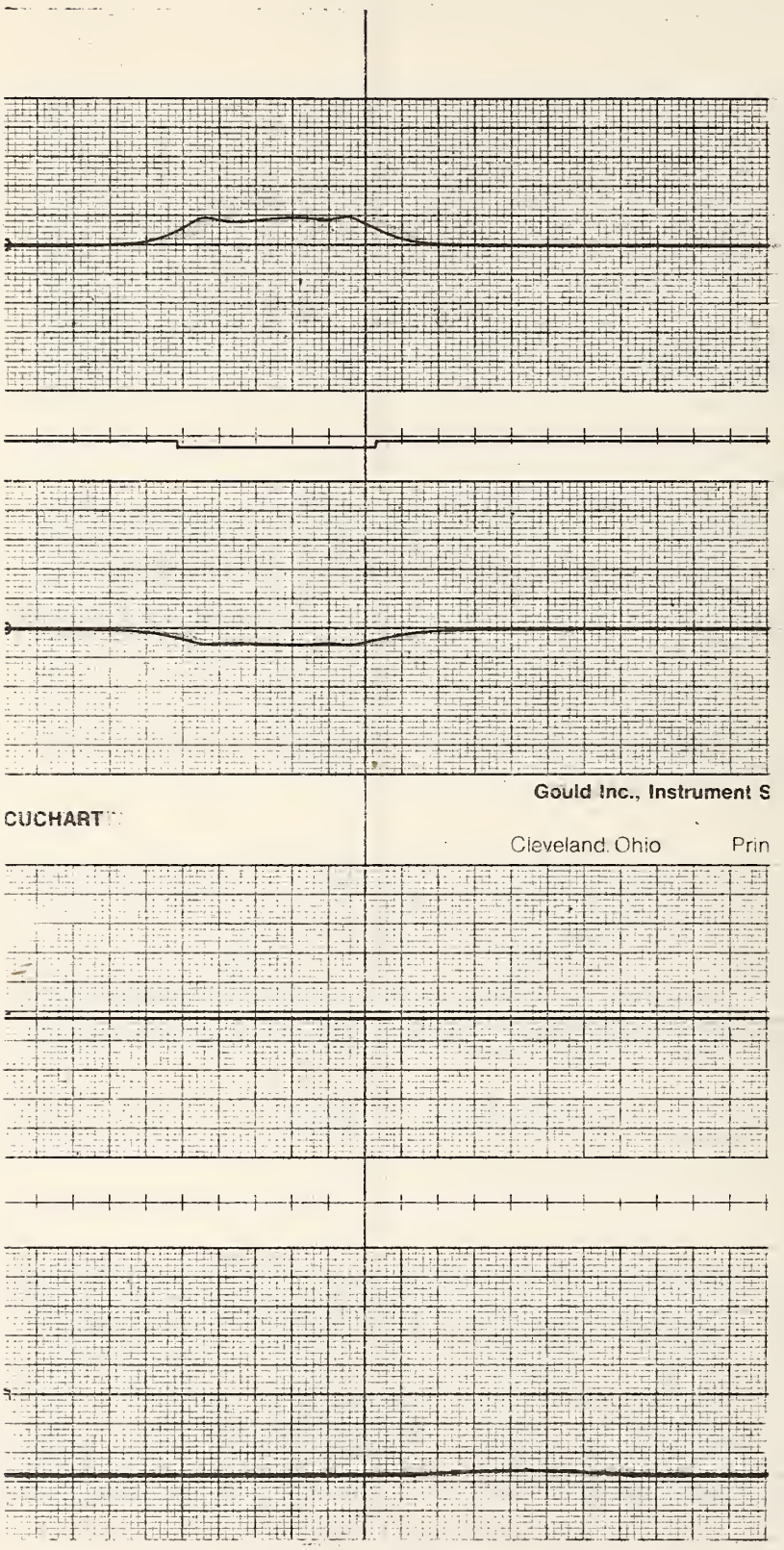
RUN 396



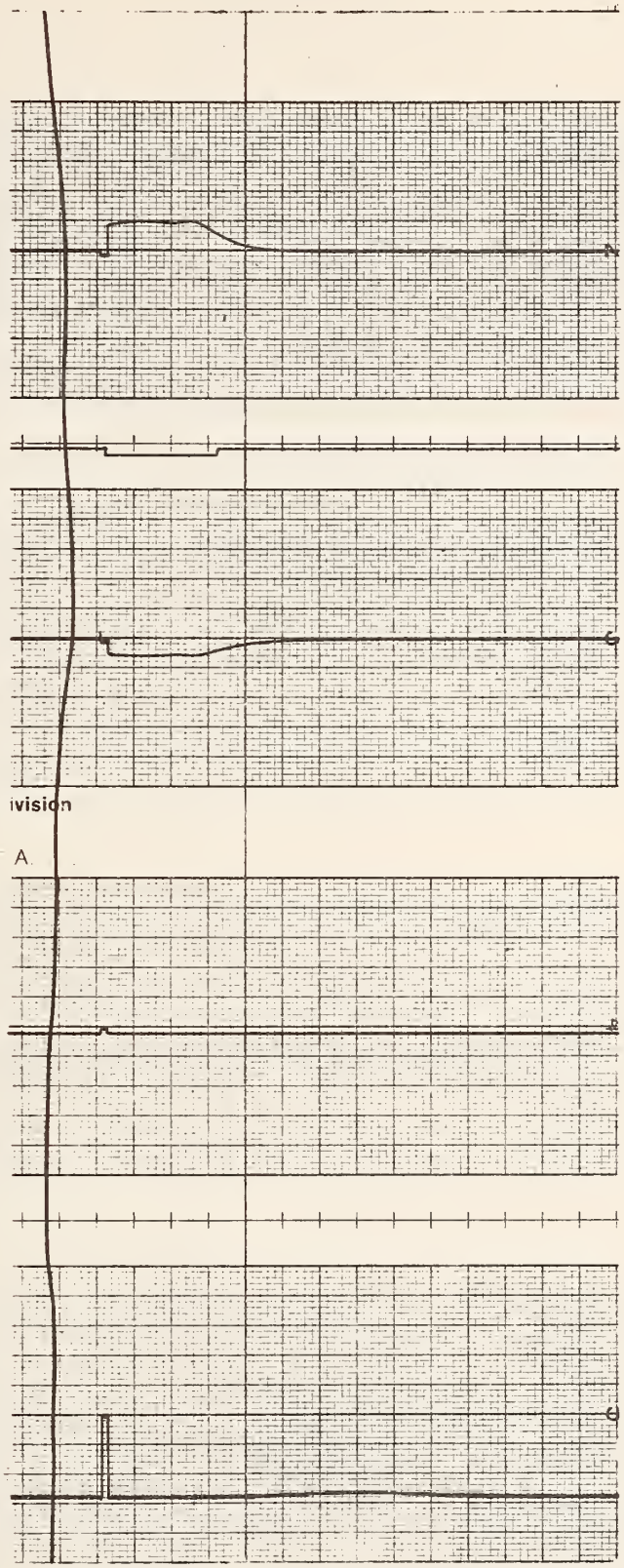
RUN 397



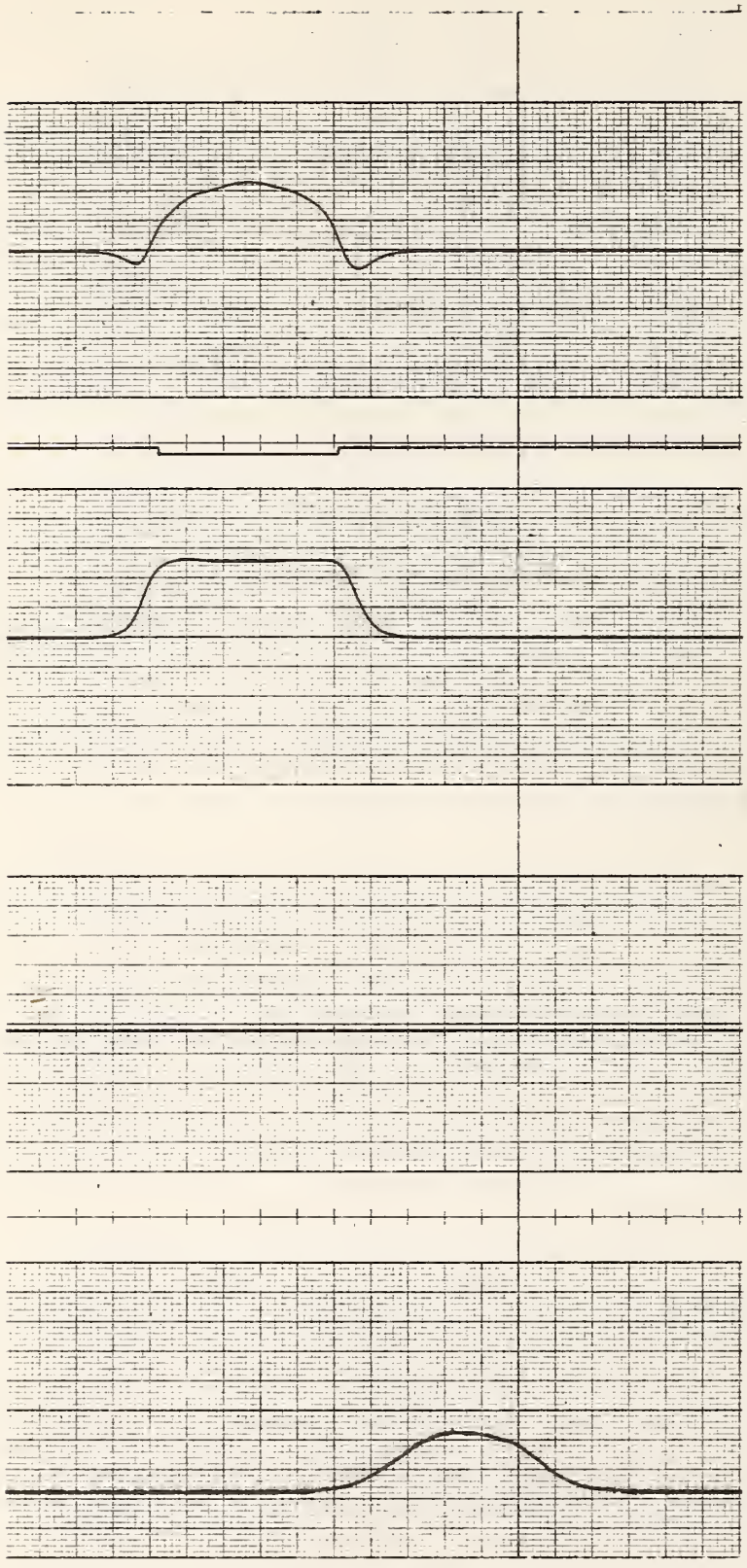
RLM 396



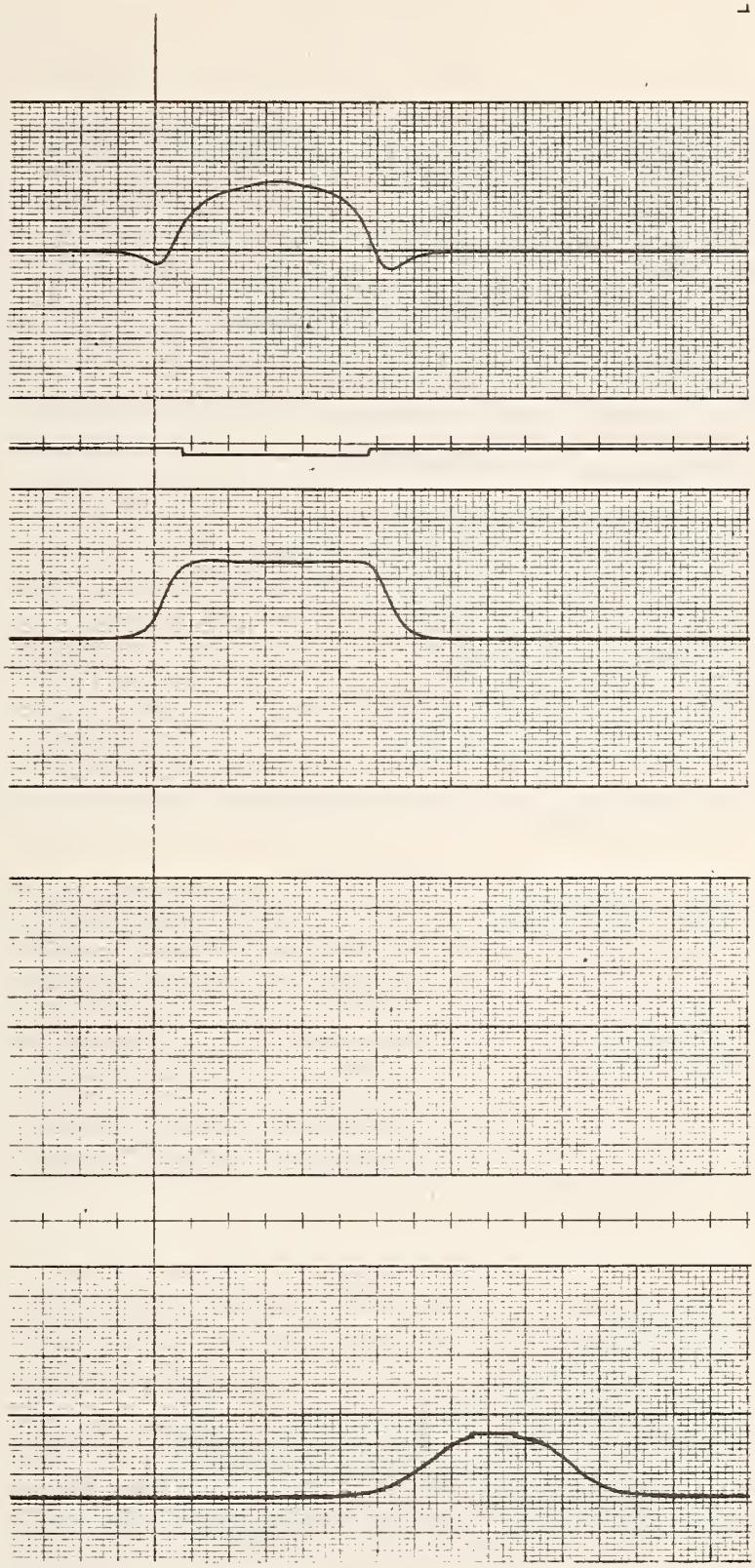
RUN 399



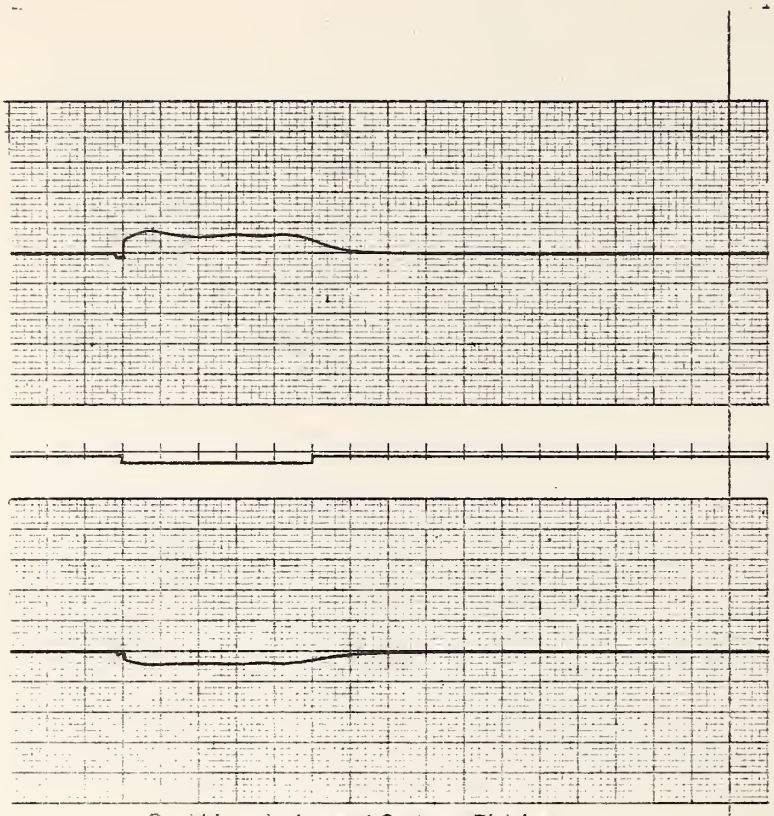
RUN 400



RUN 401



RUN 402



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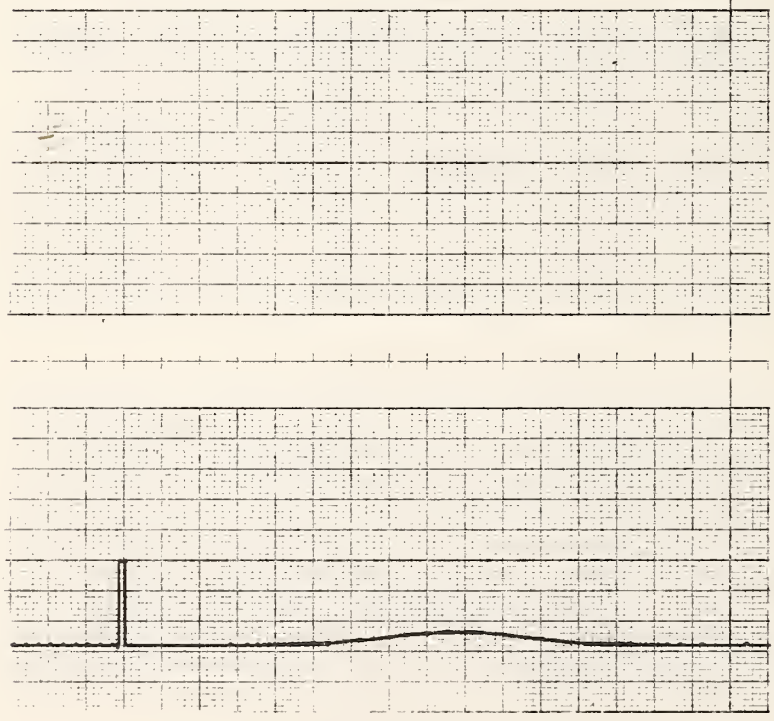
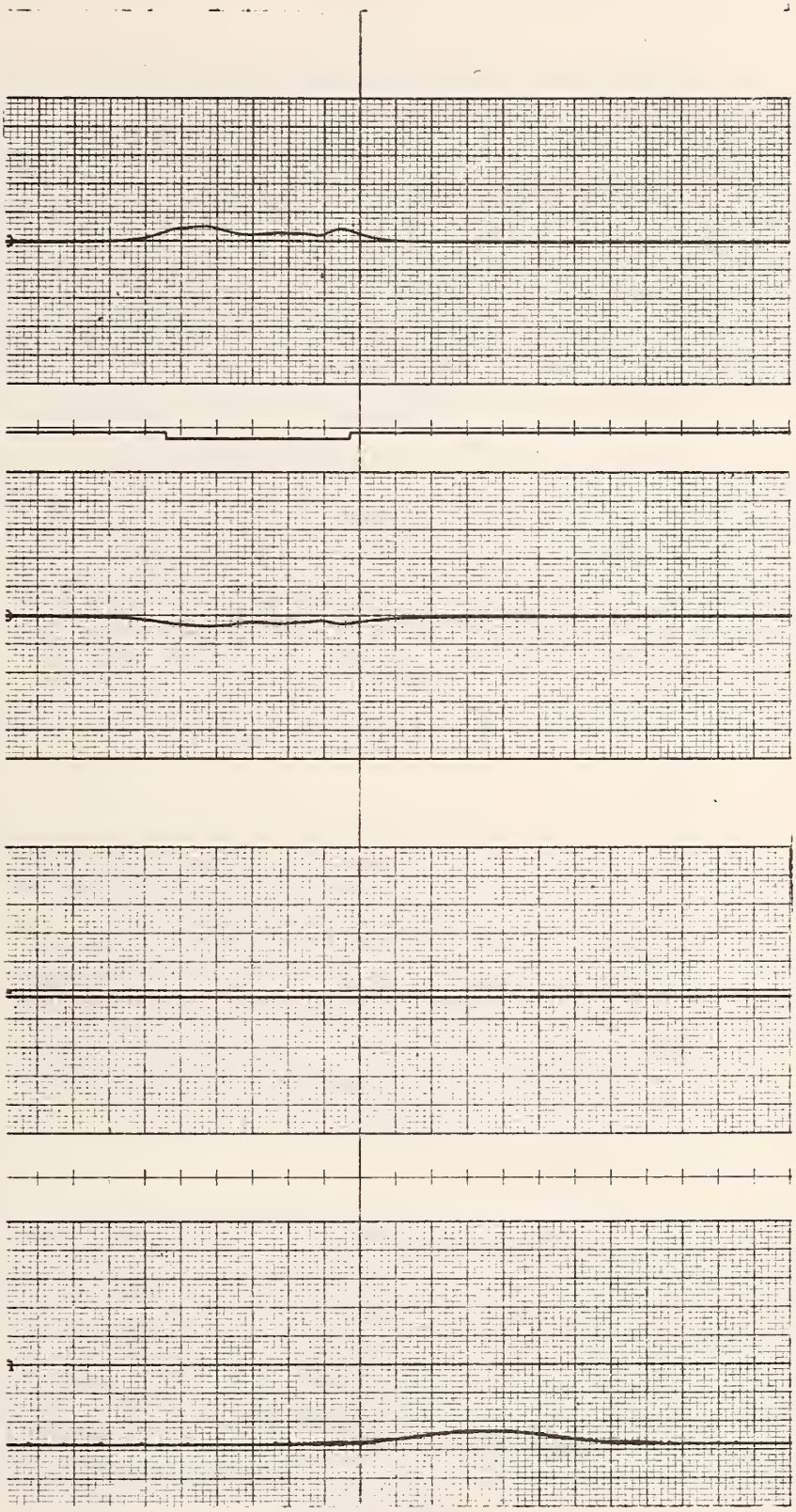
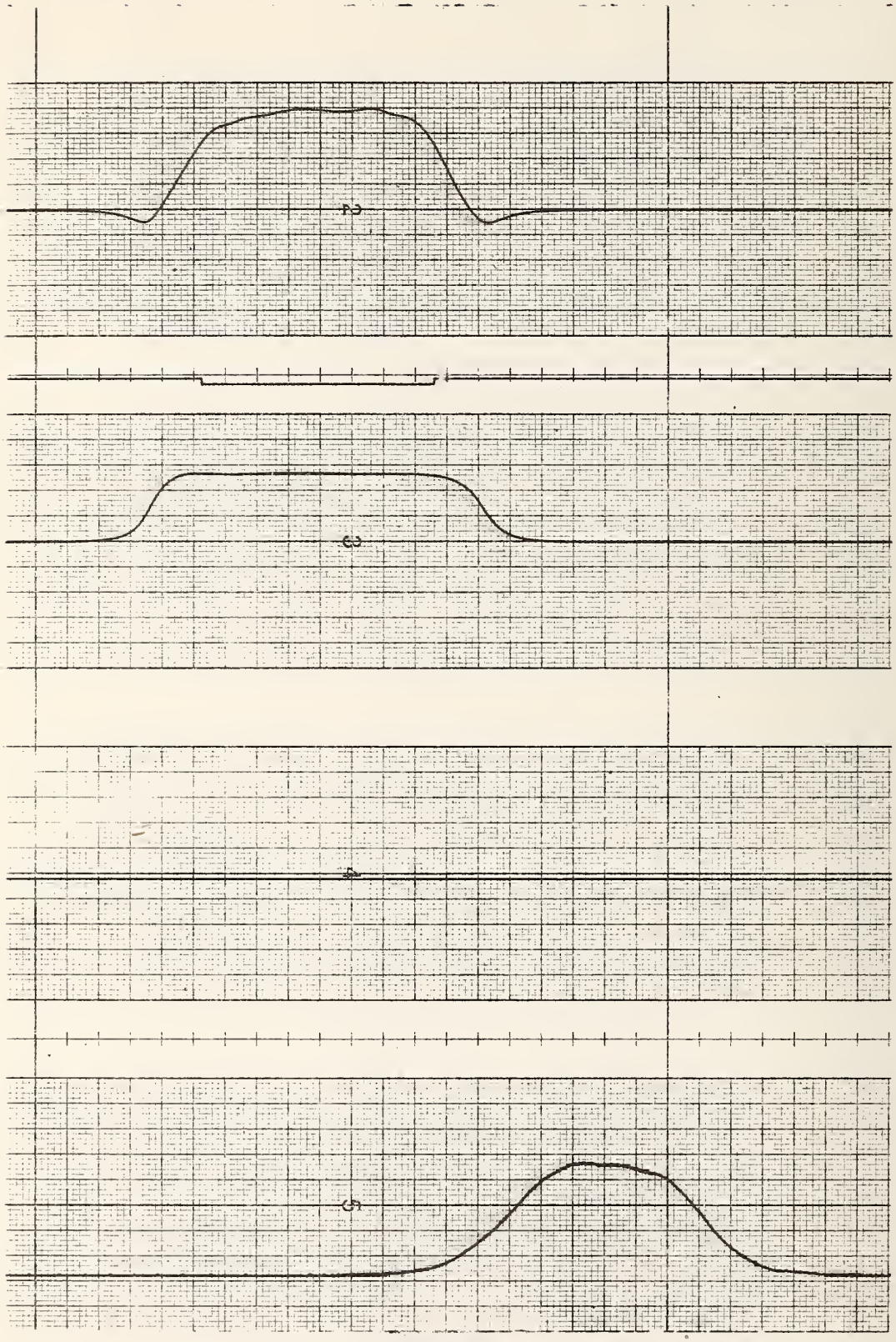


RUN 403



RUN 404



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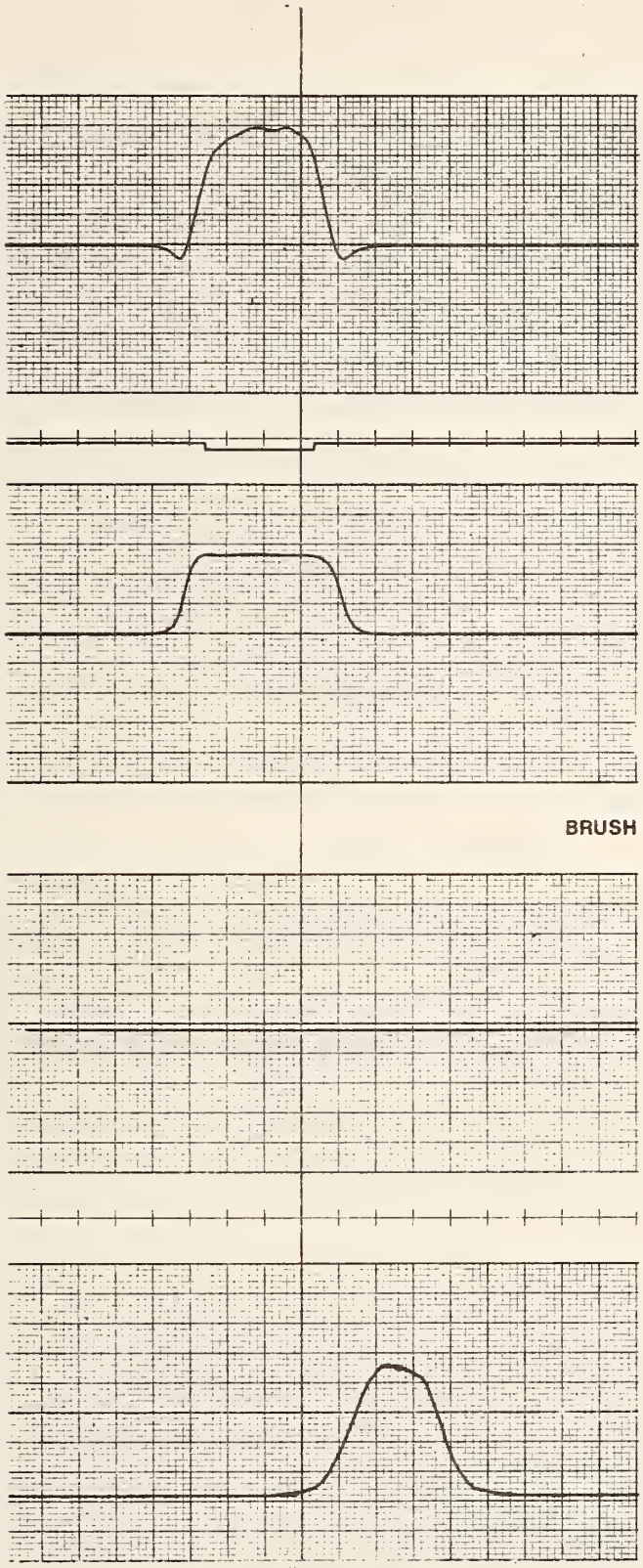

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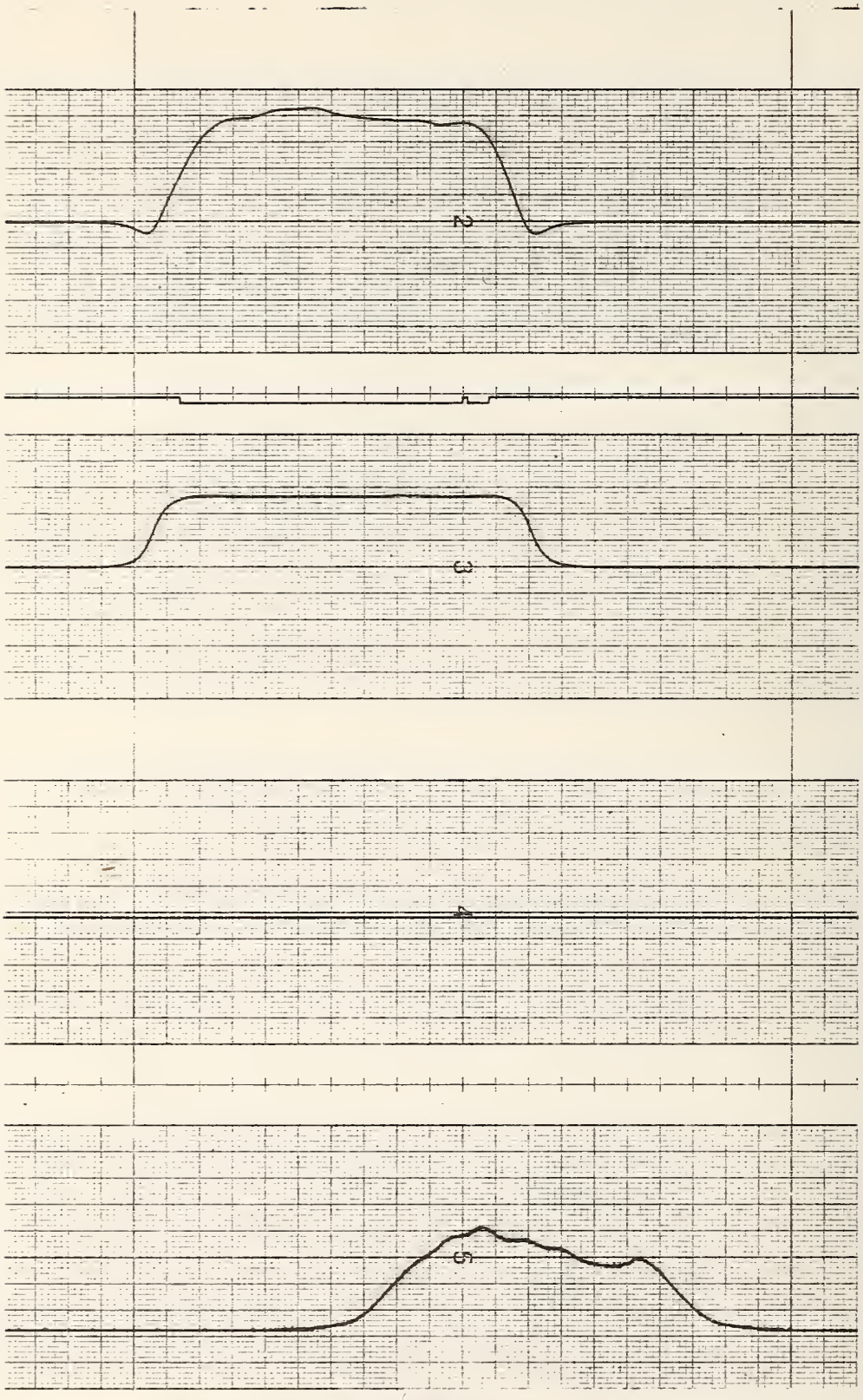

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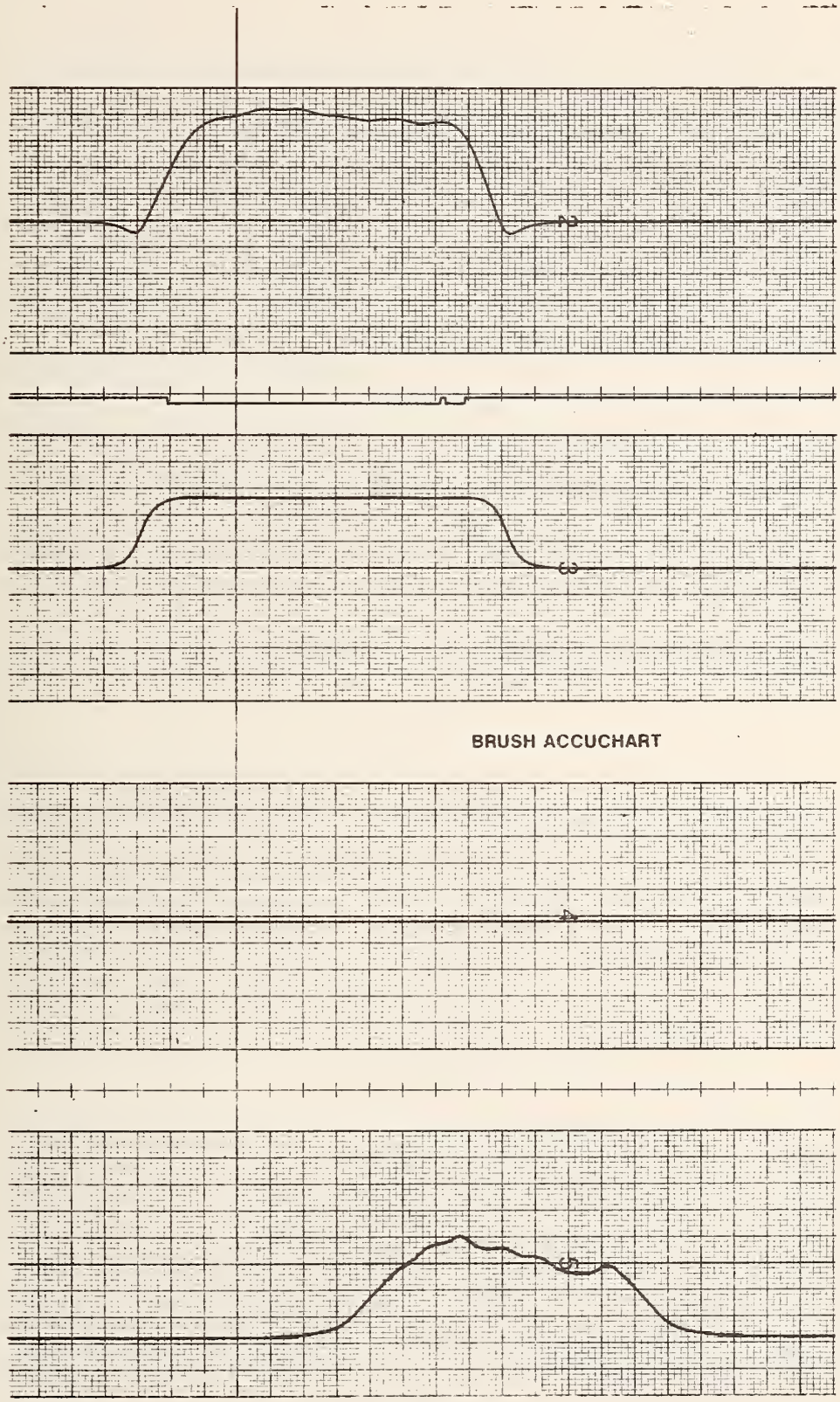

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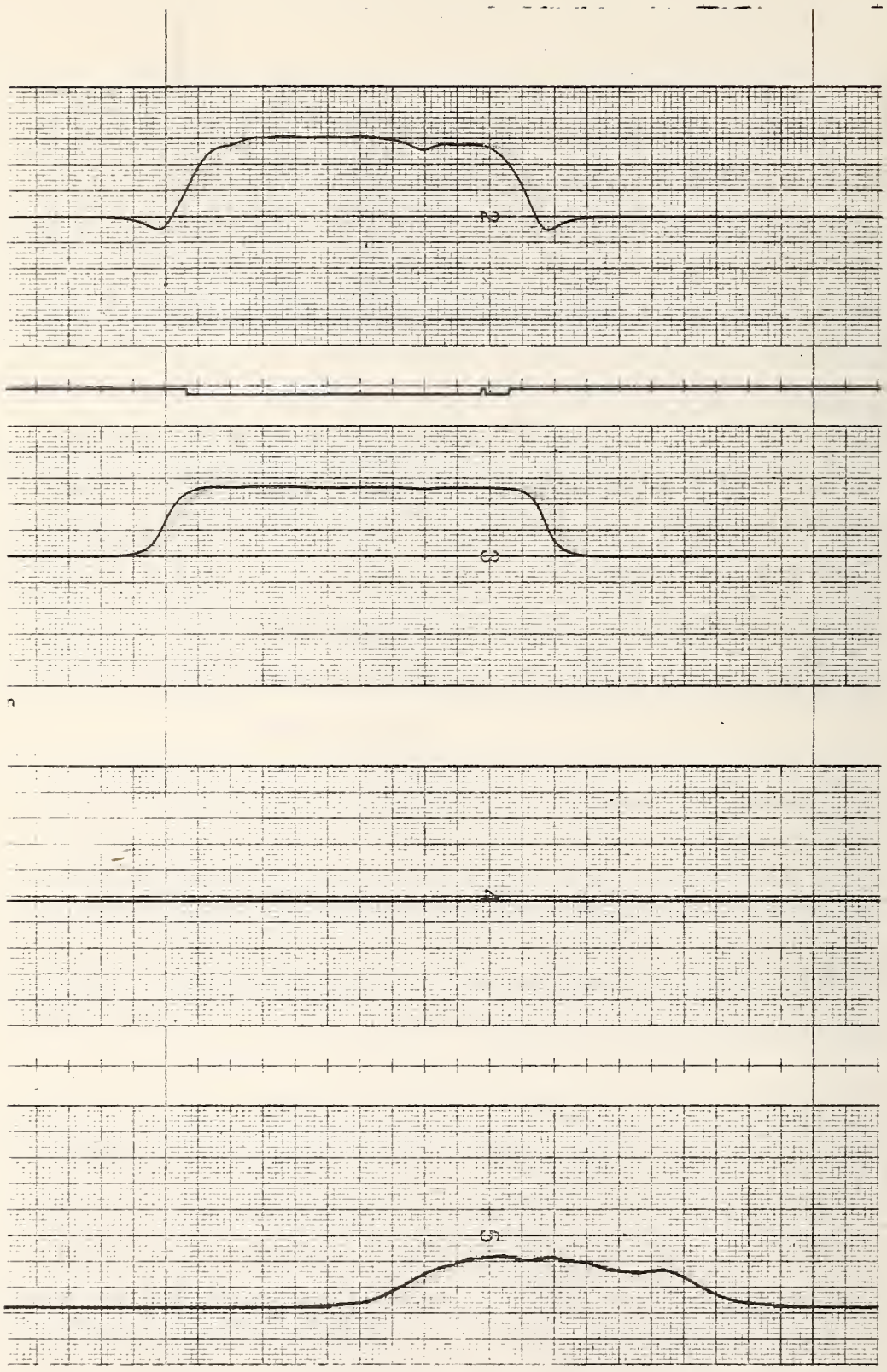

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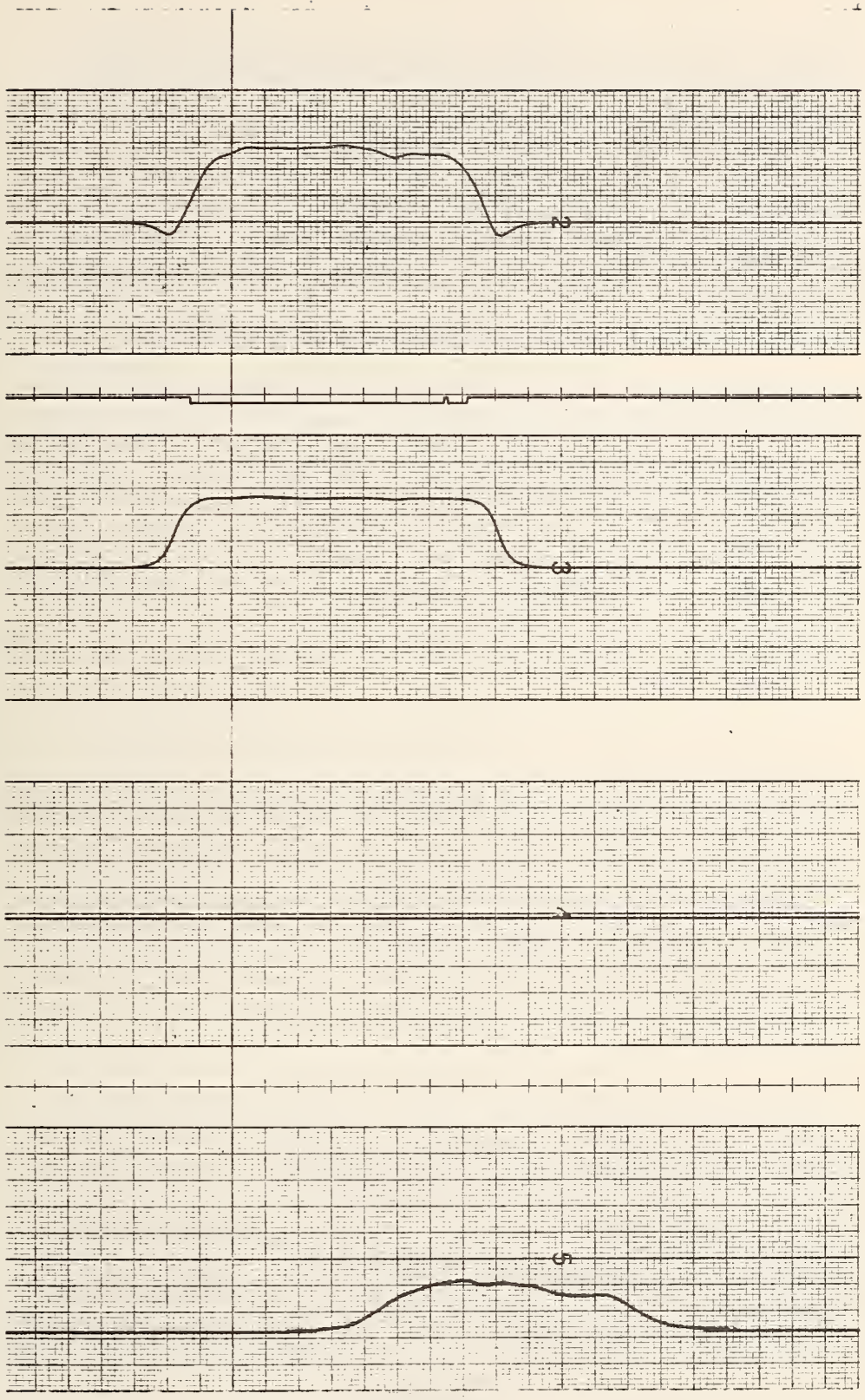

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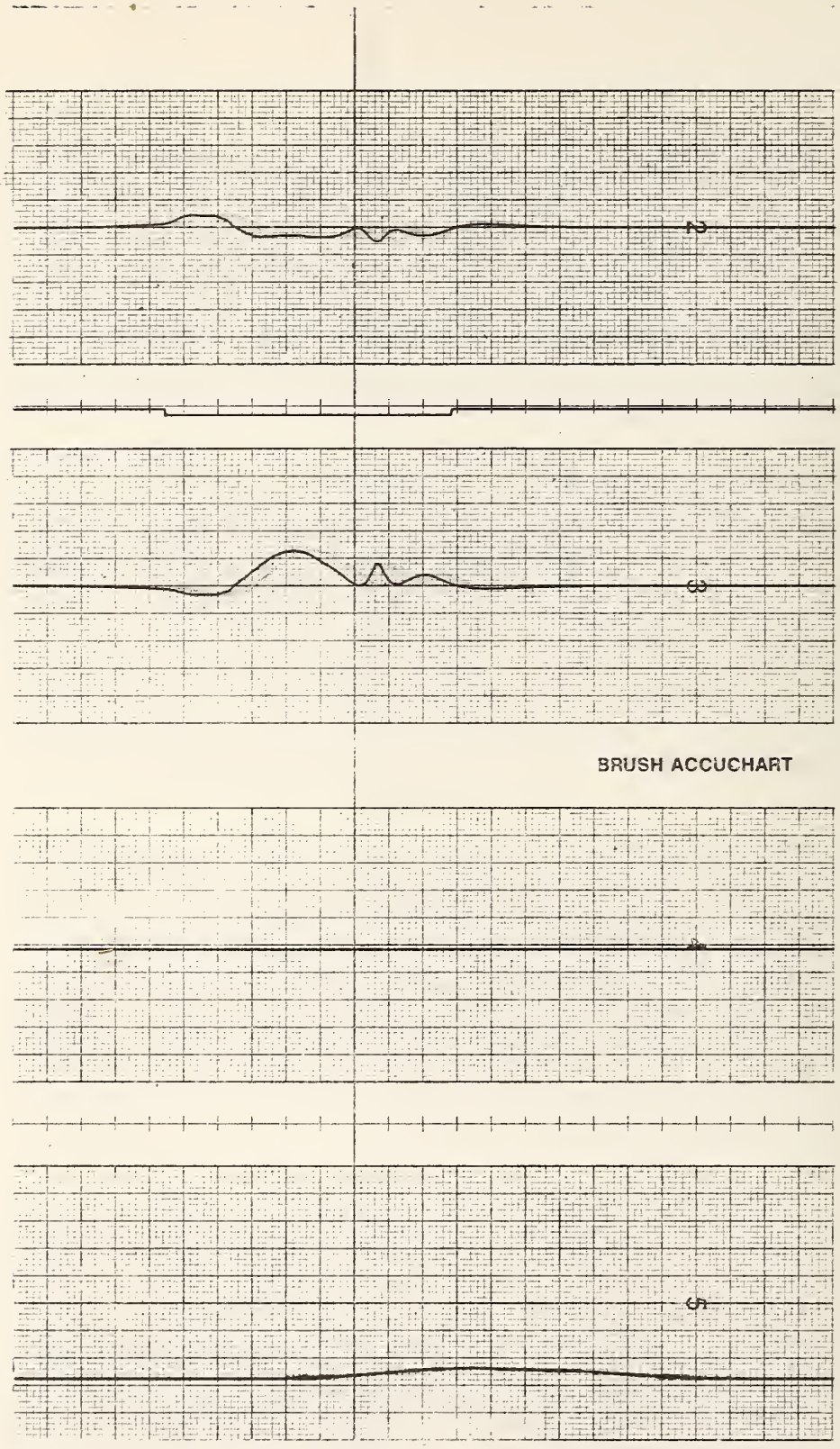

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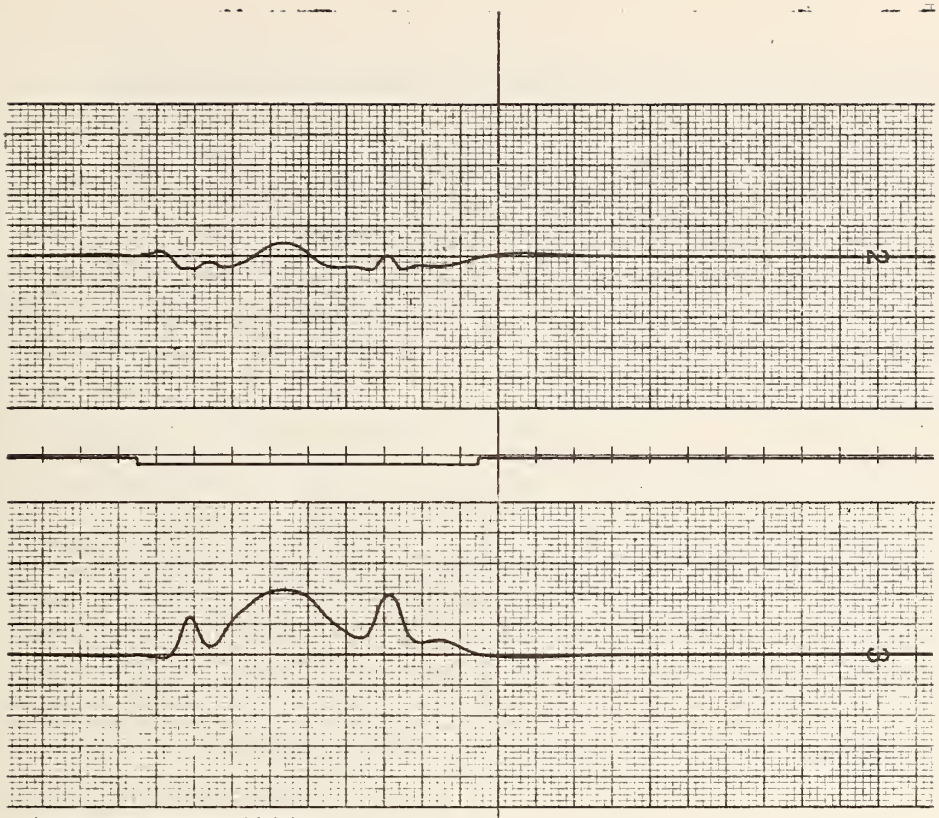

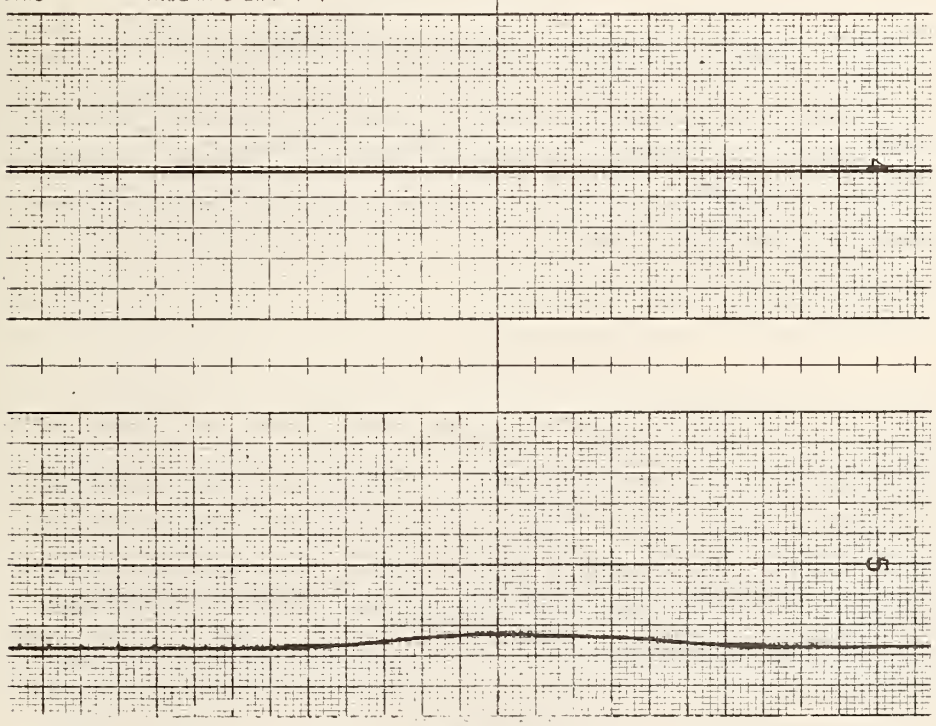

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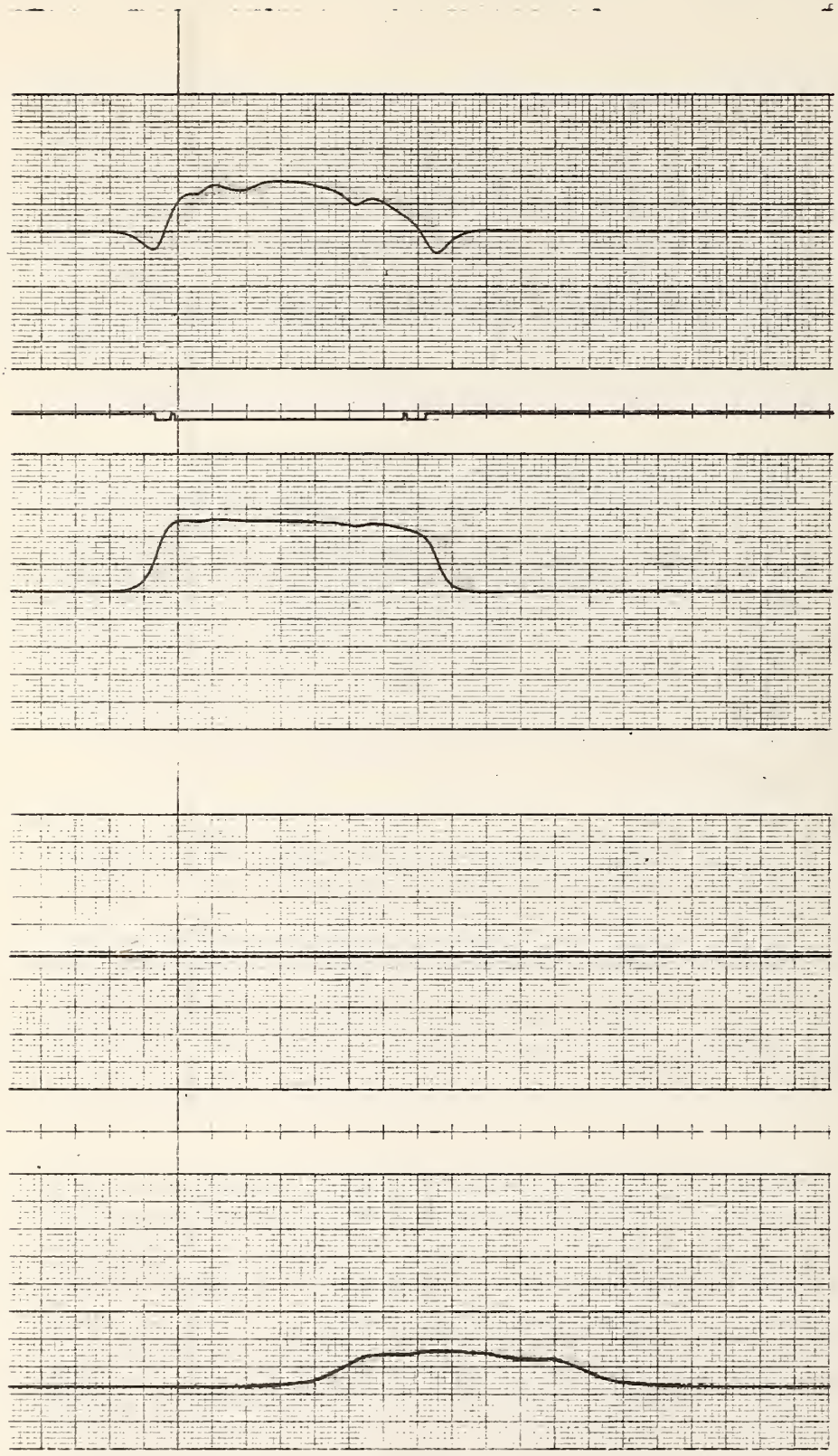
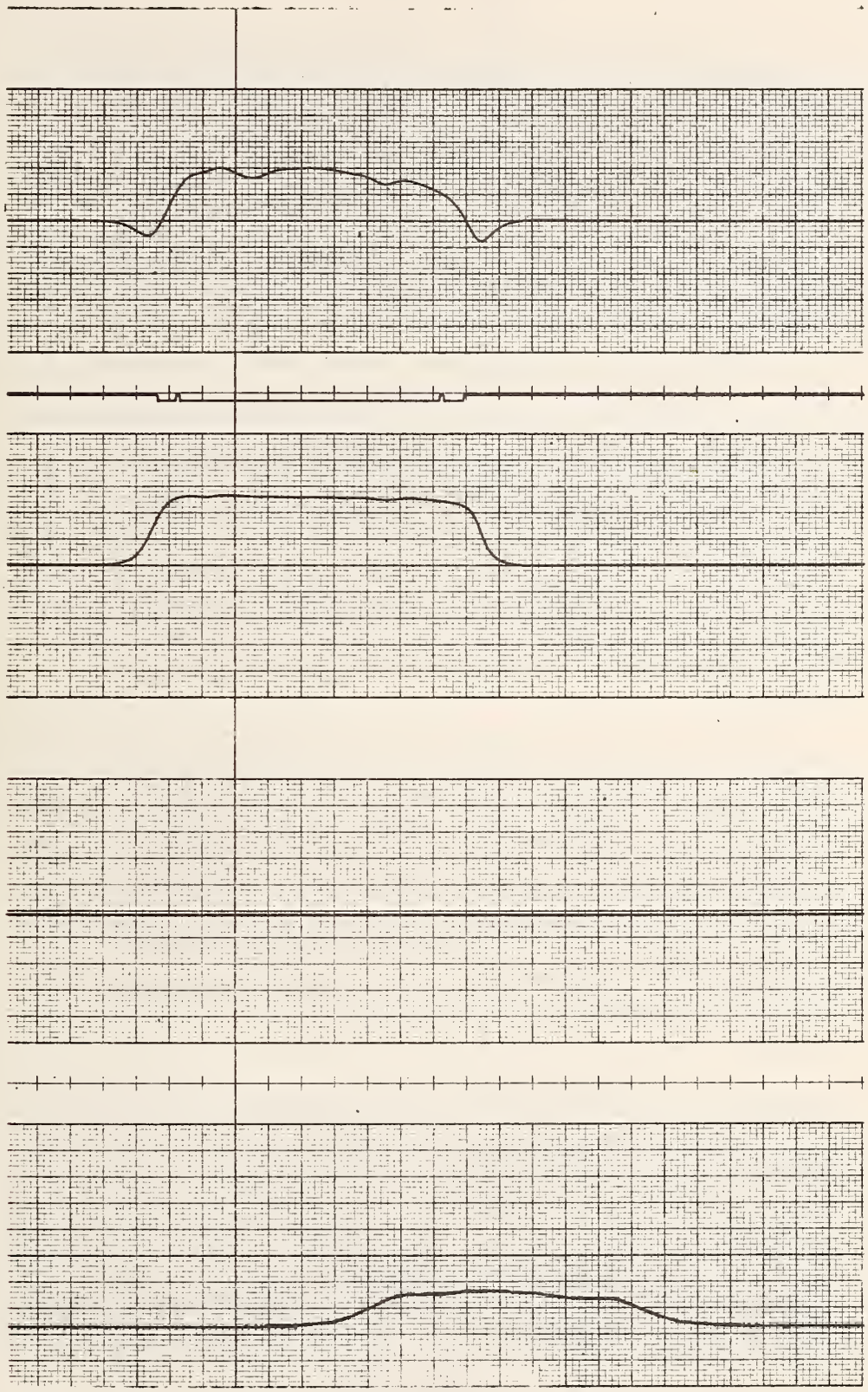
RUN 412



RUN 413.



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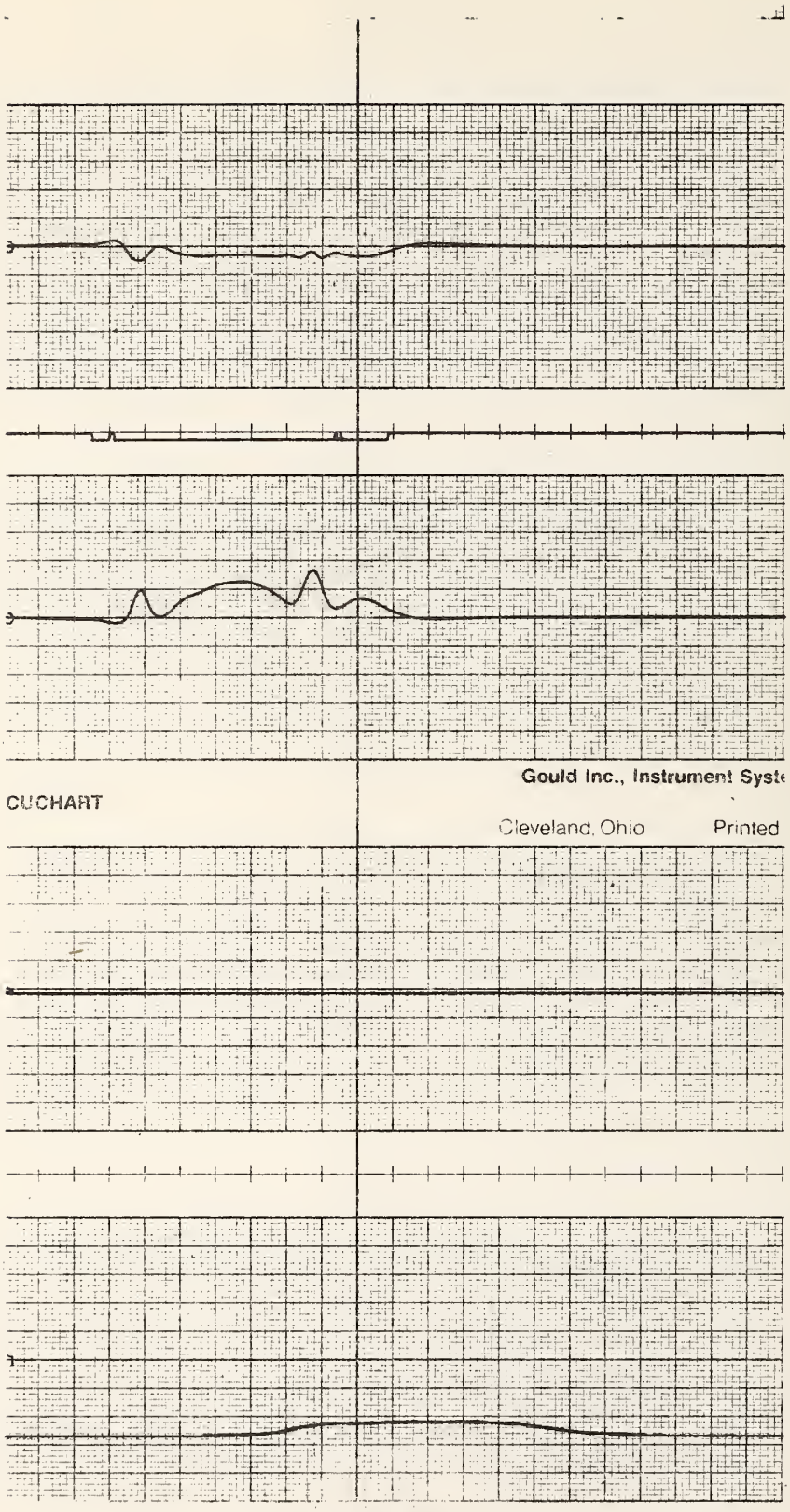
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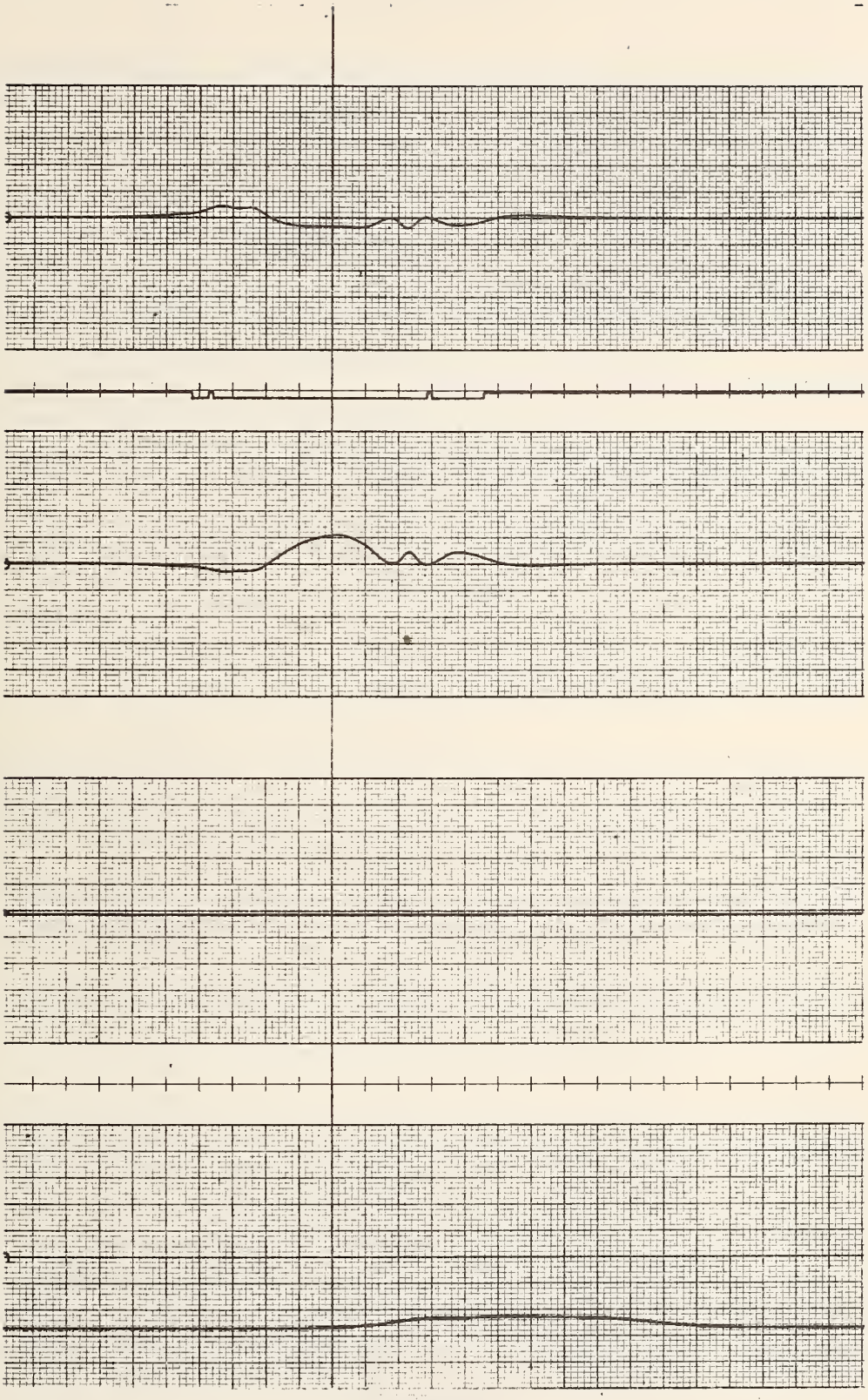
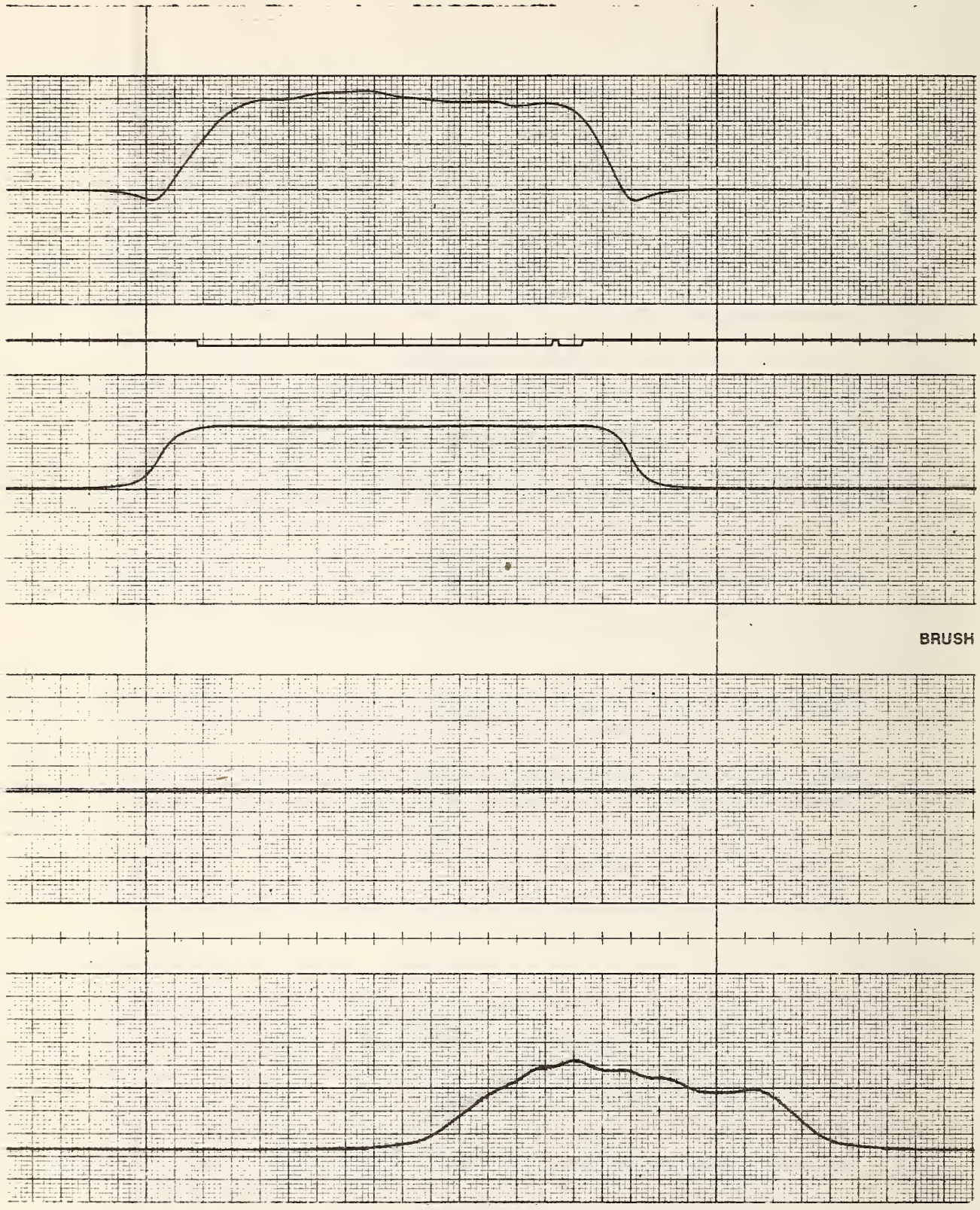
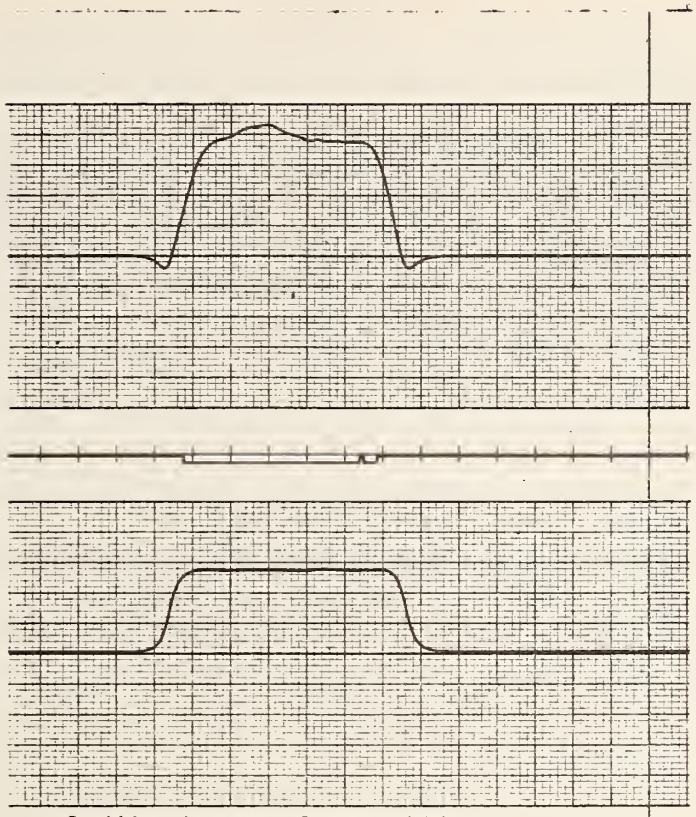
RUN 415



RUN 416



RUN 417



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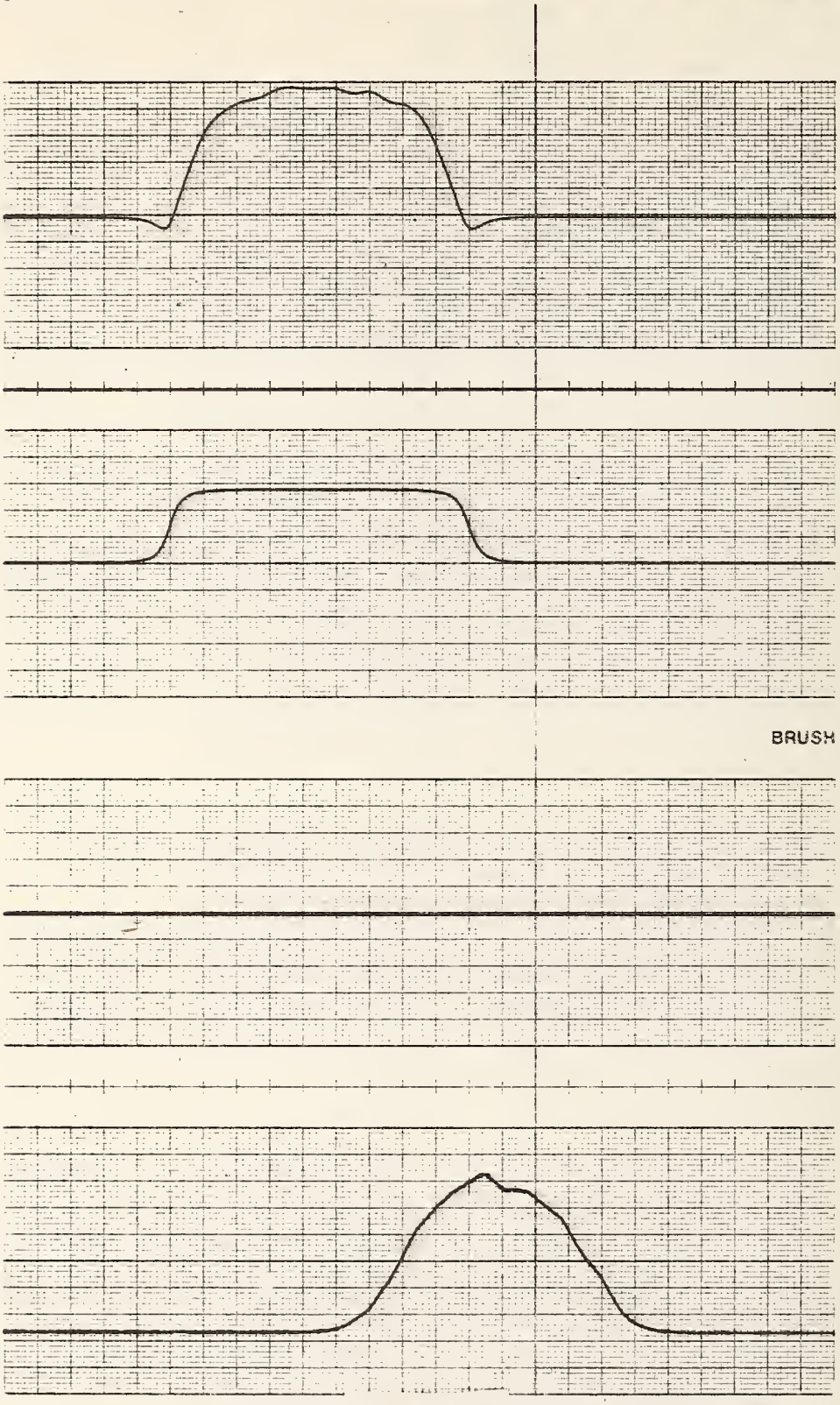
RUN 418



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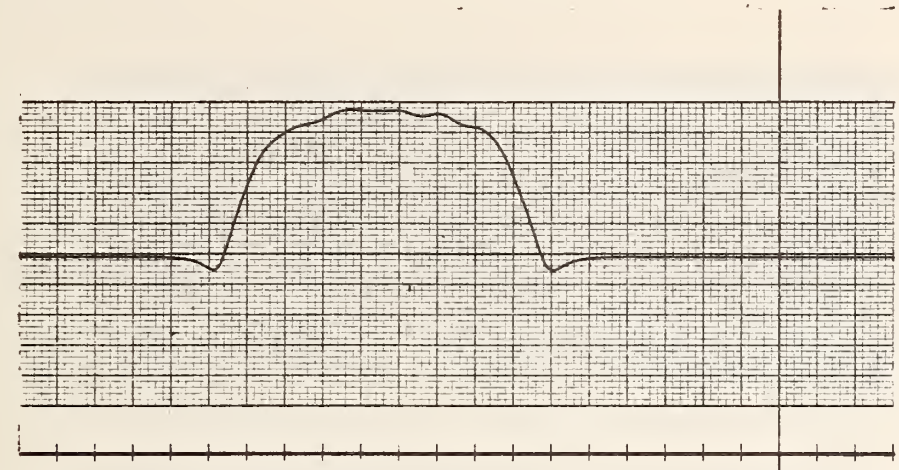

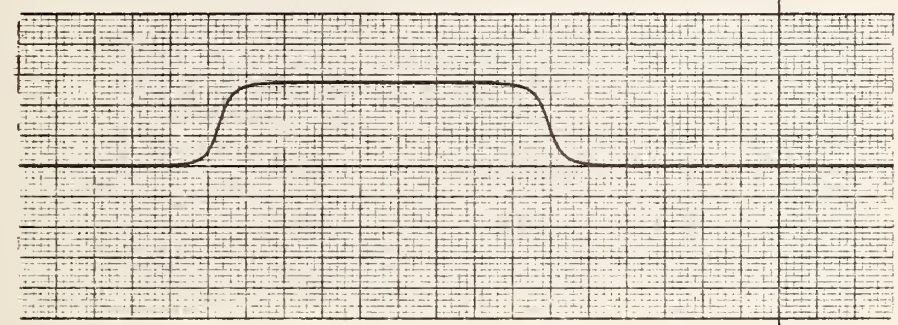

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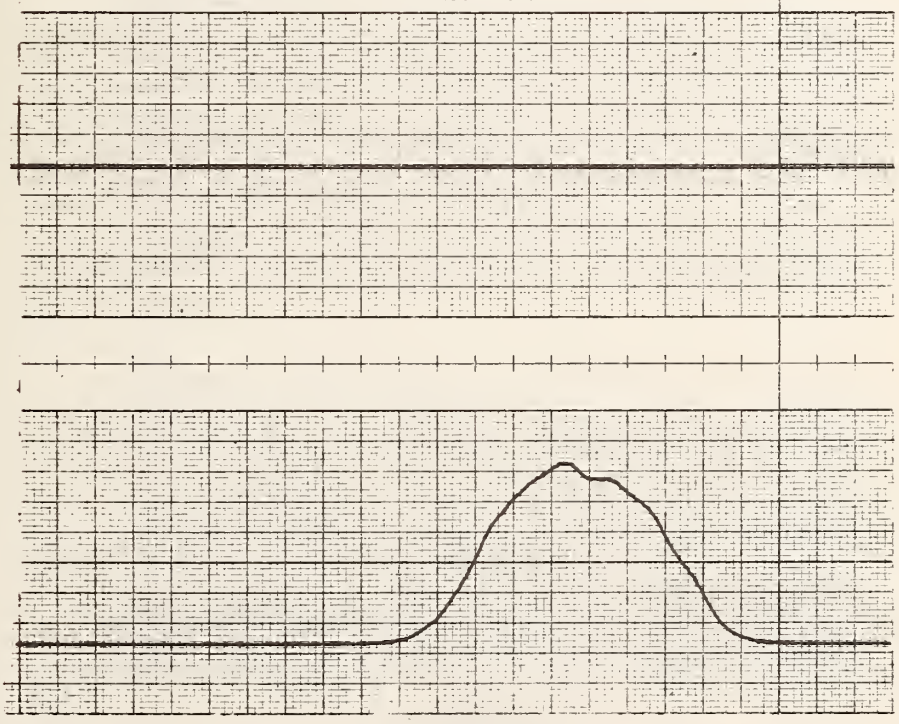

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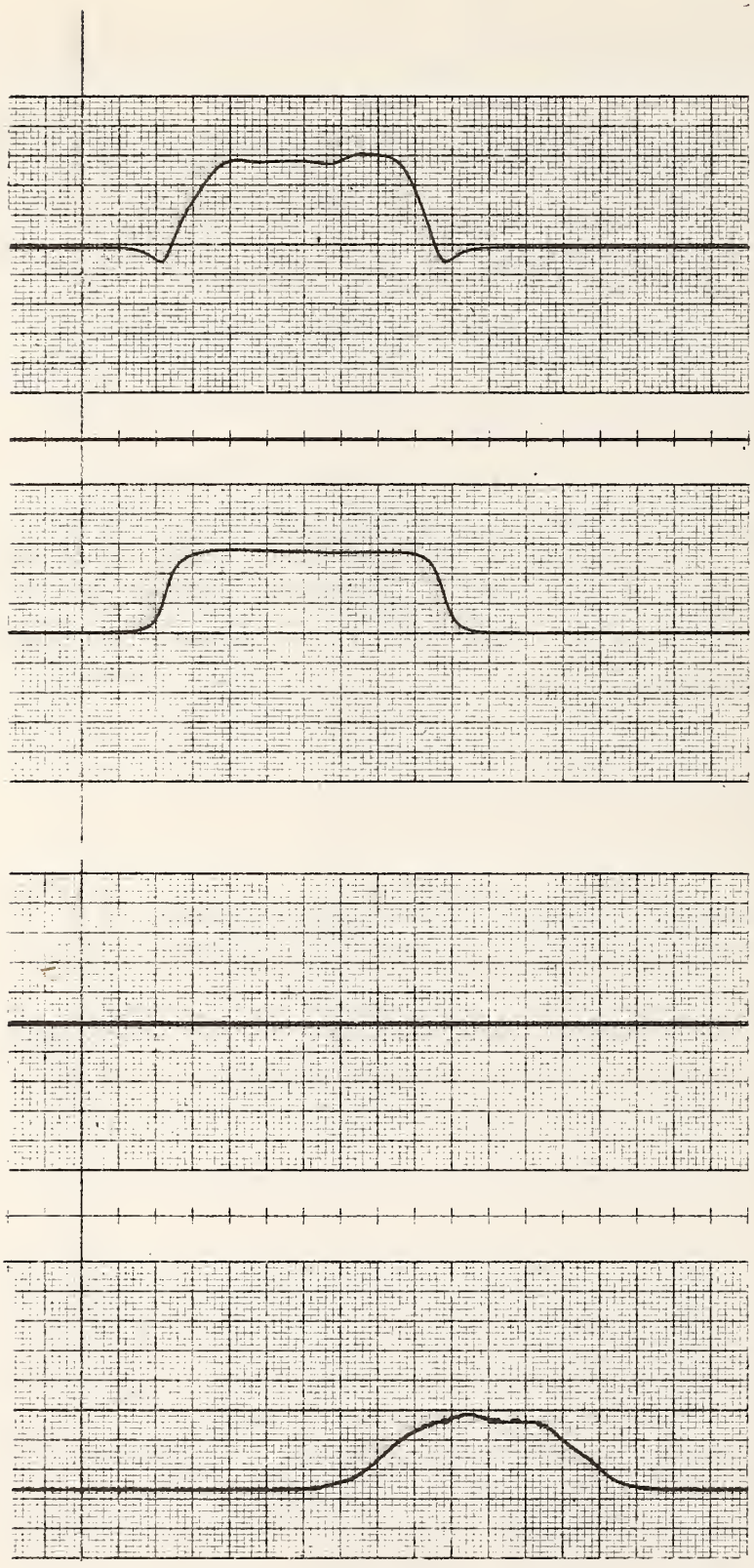

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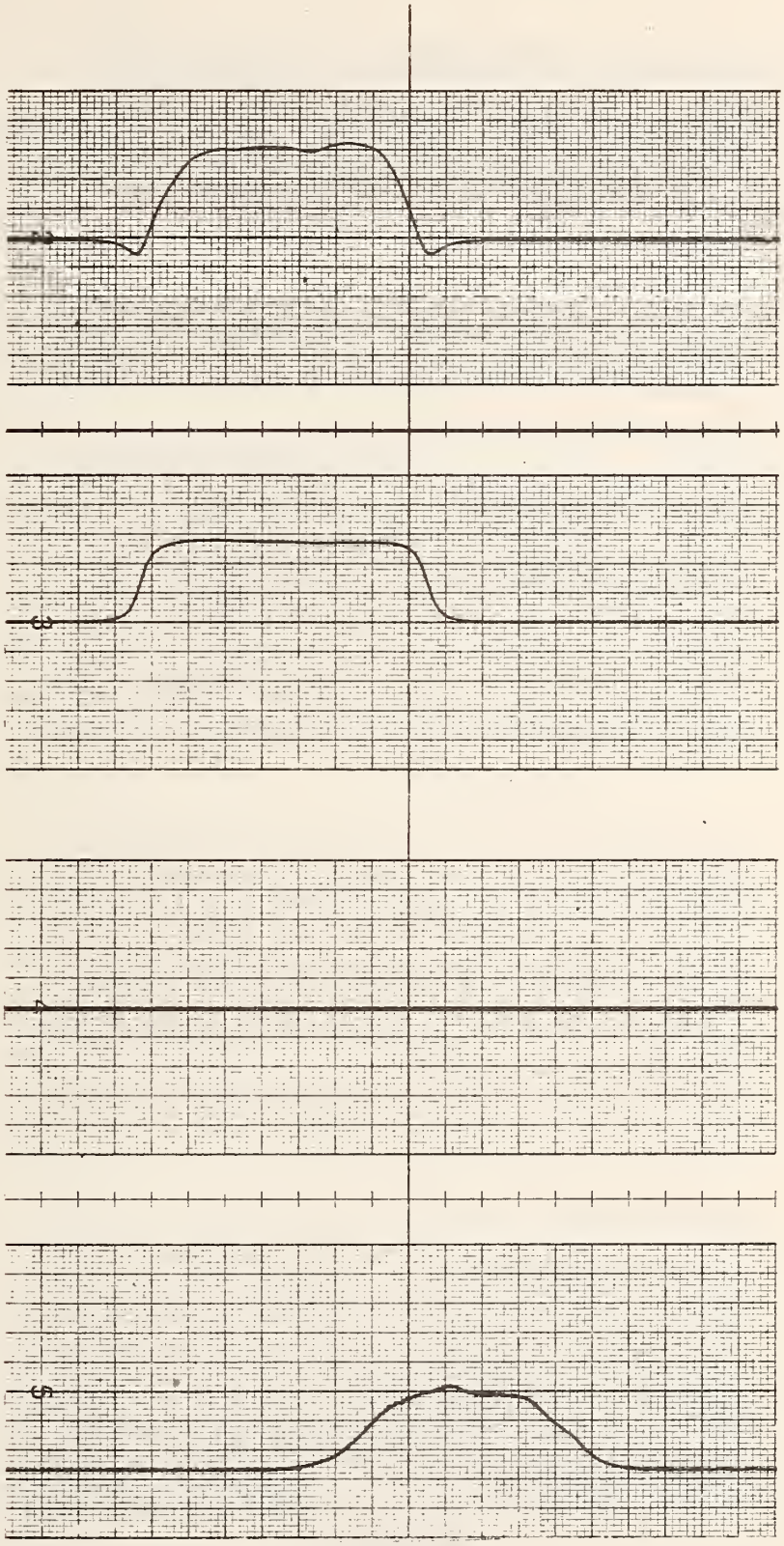

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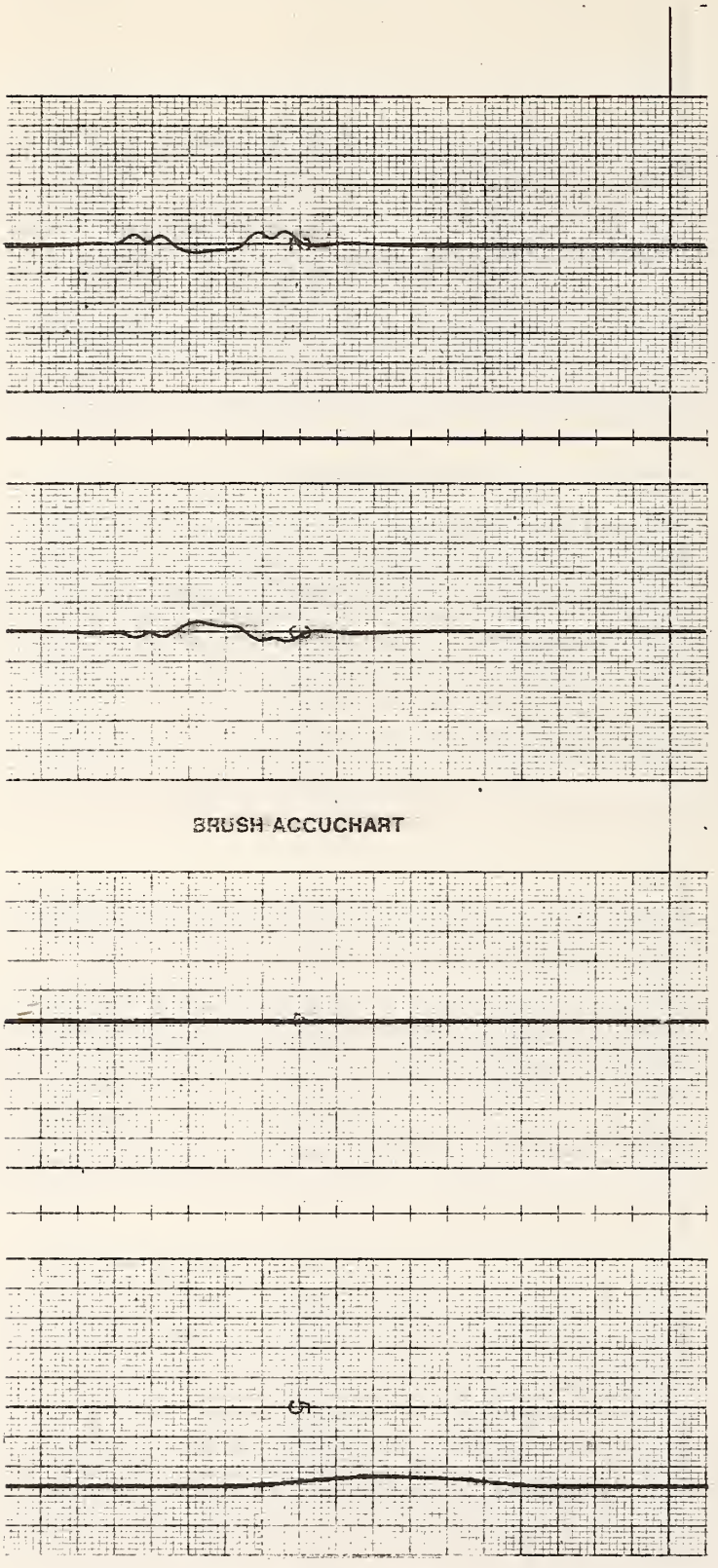

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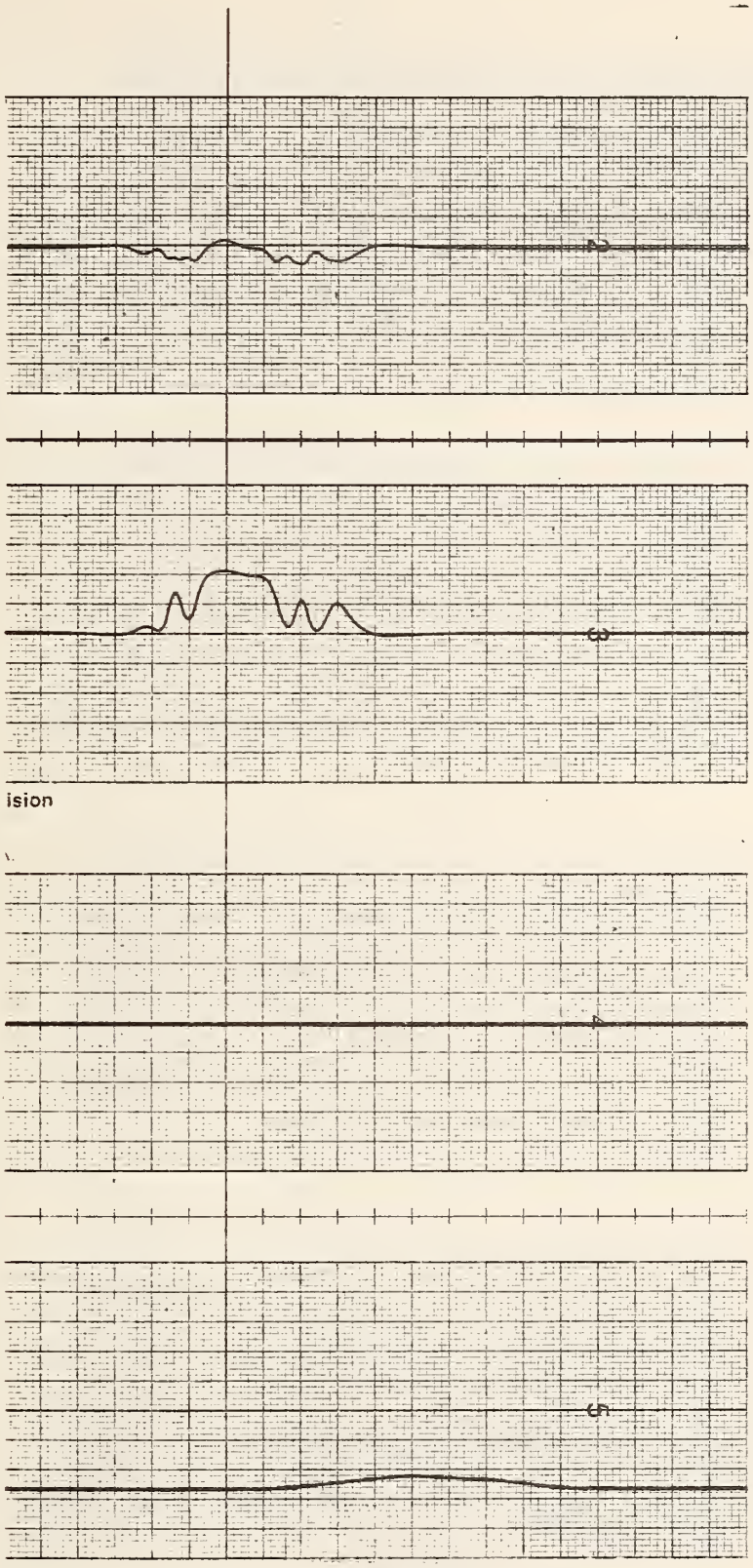

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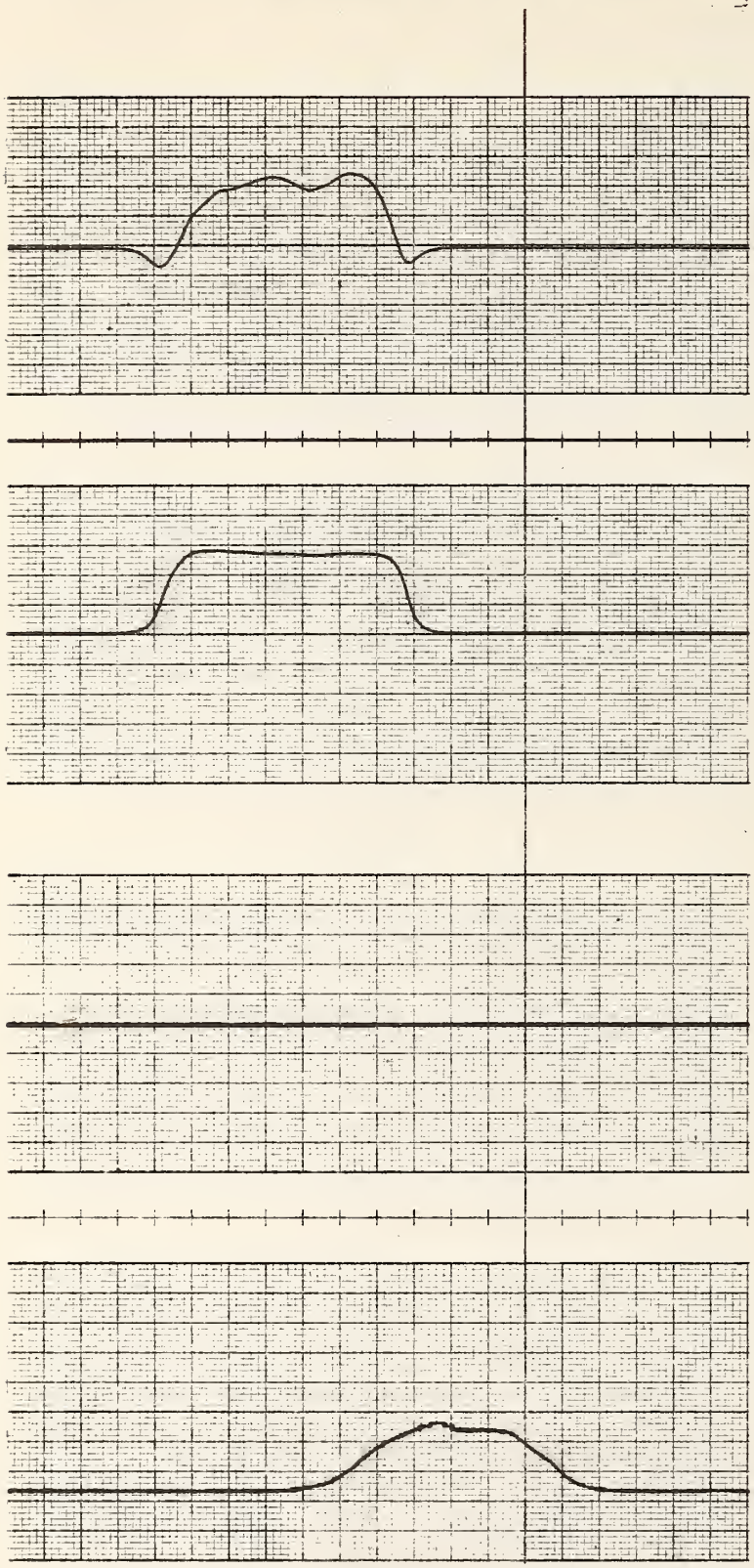

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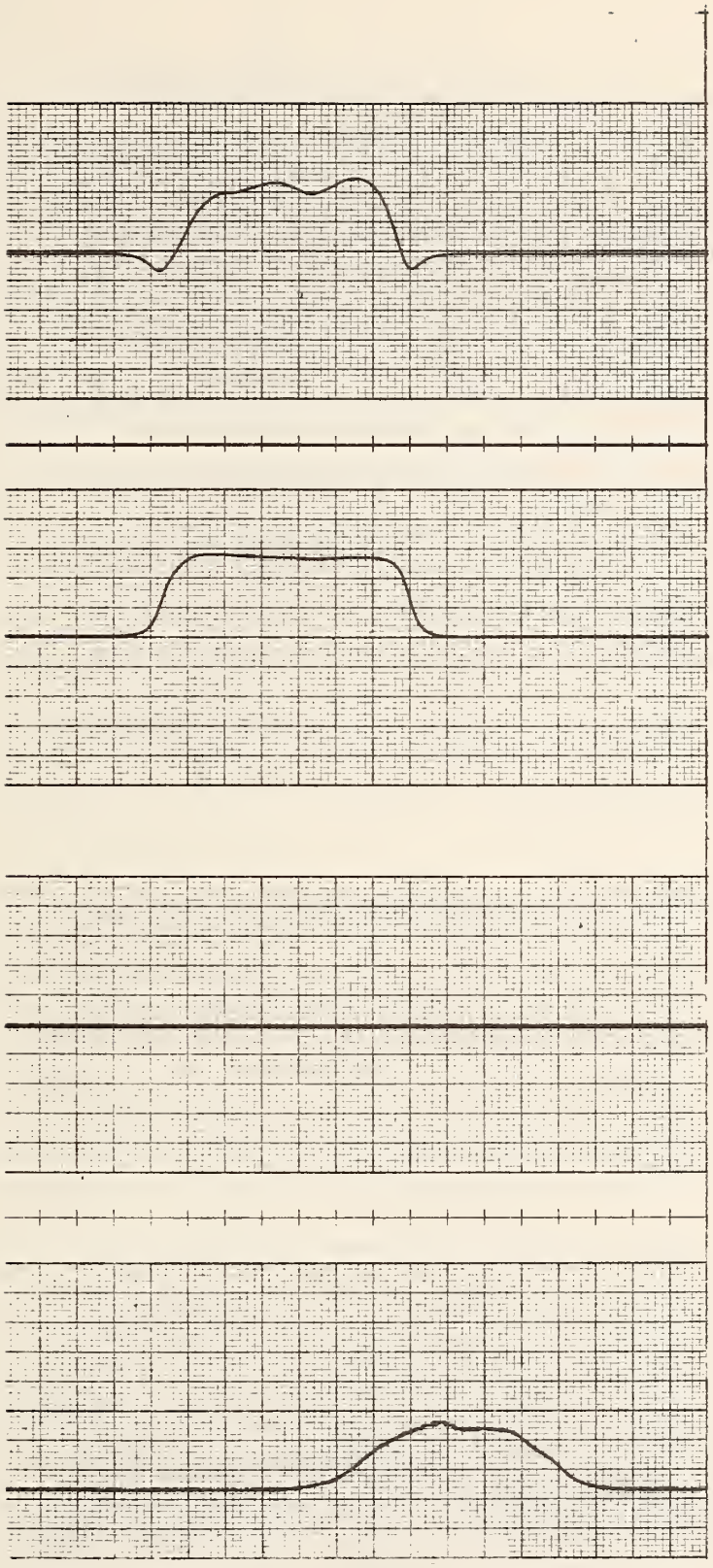

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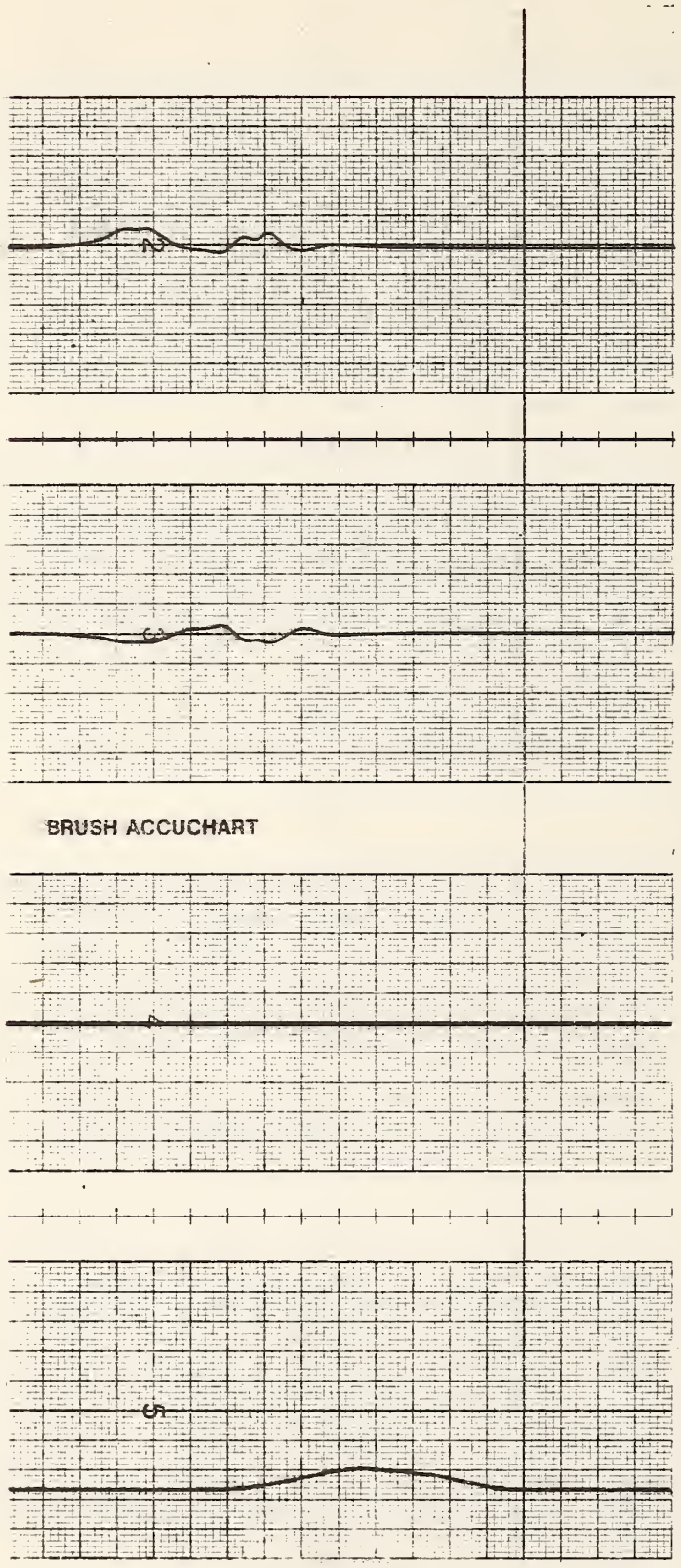

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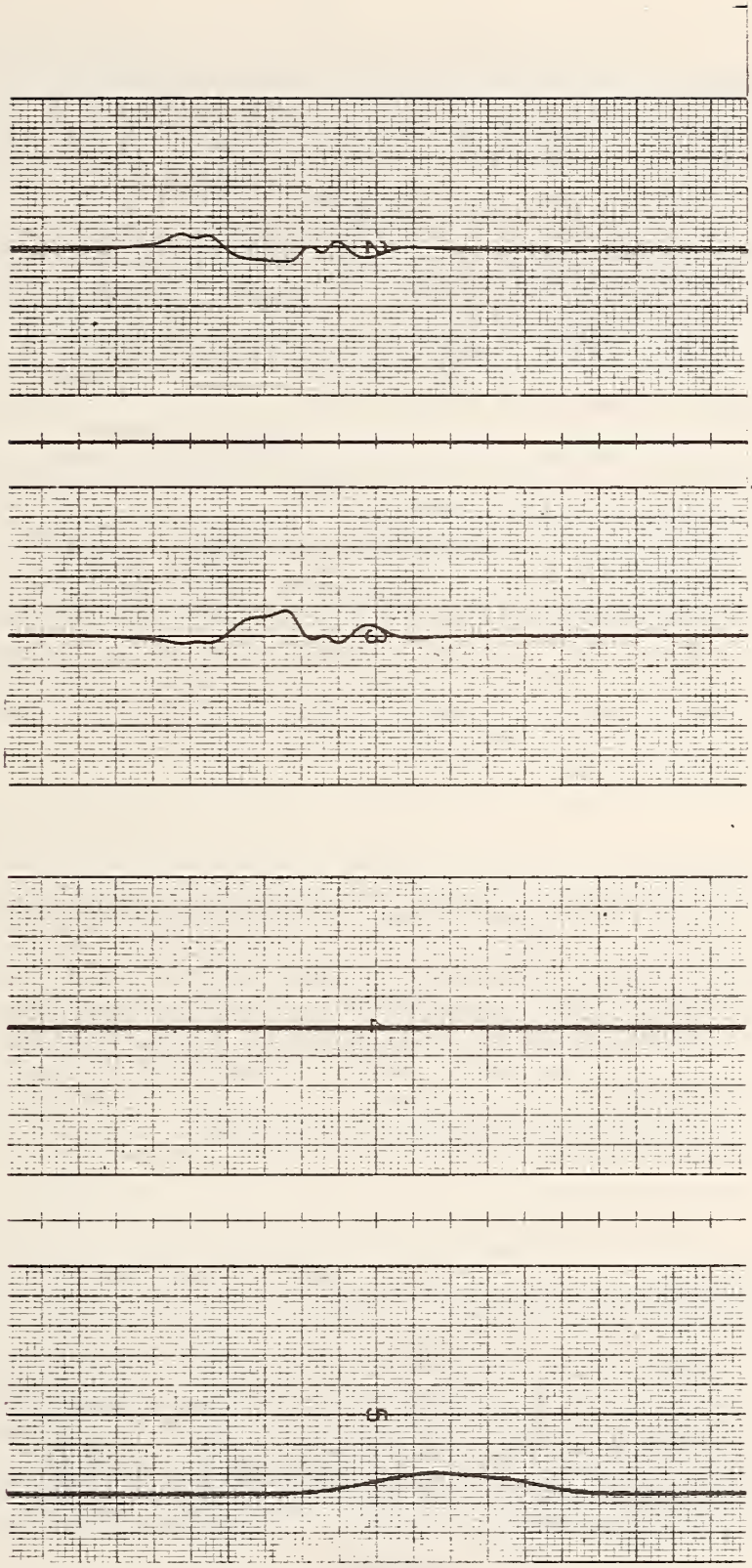

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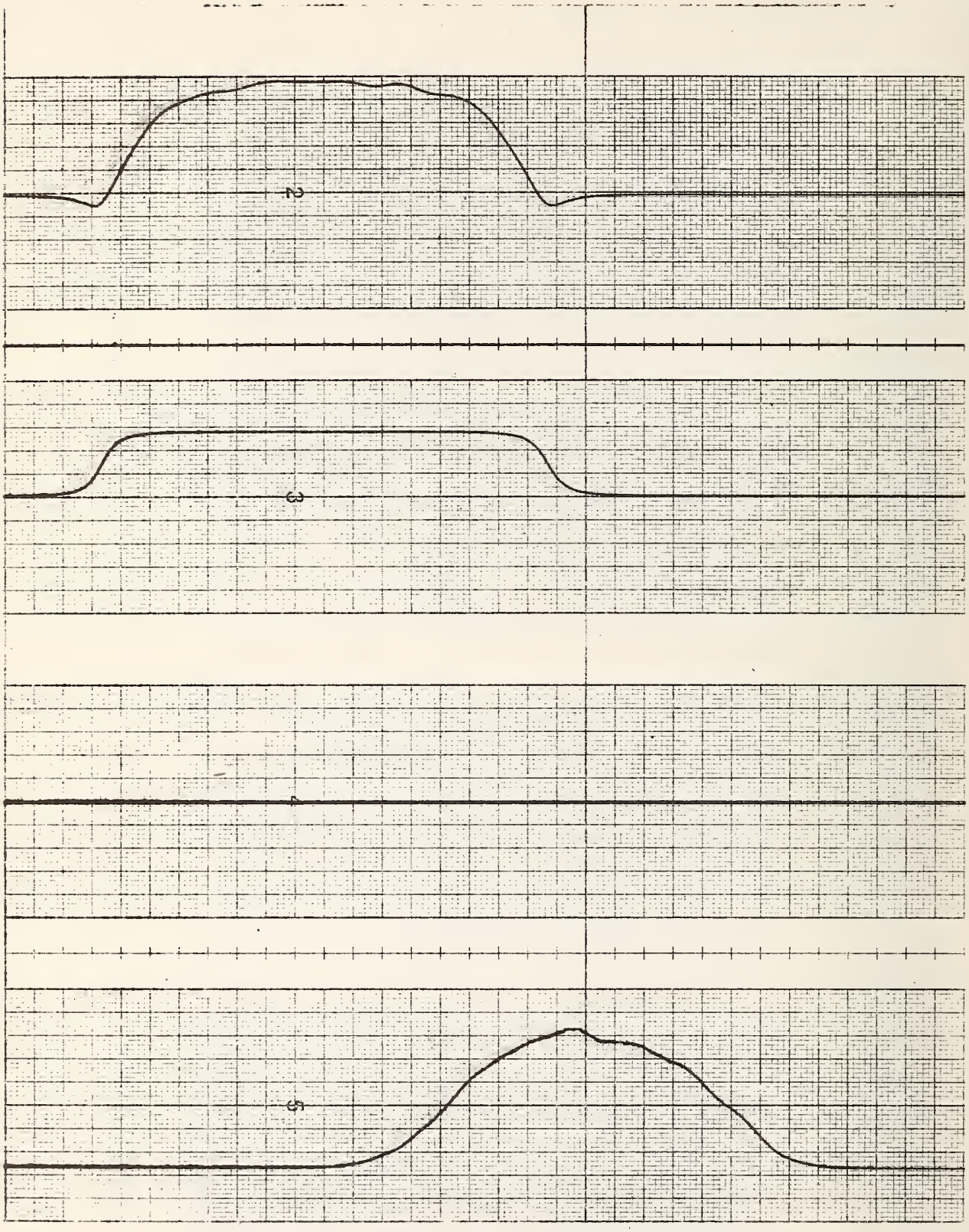

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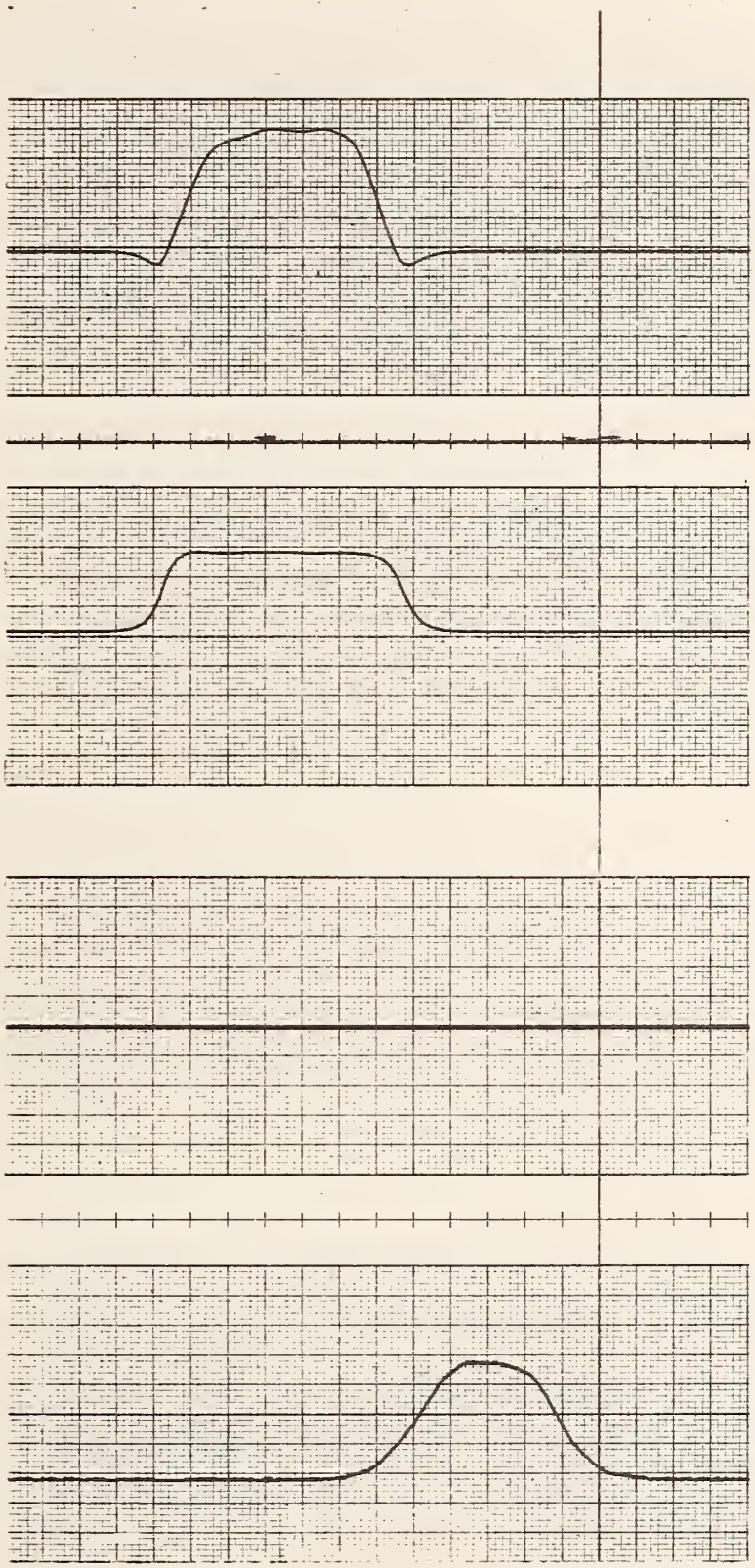

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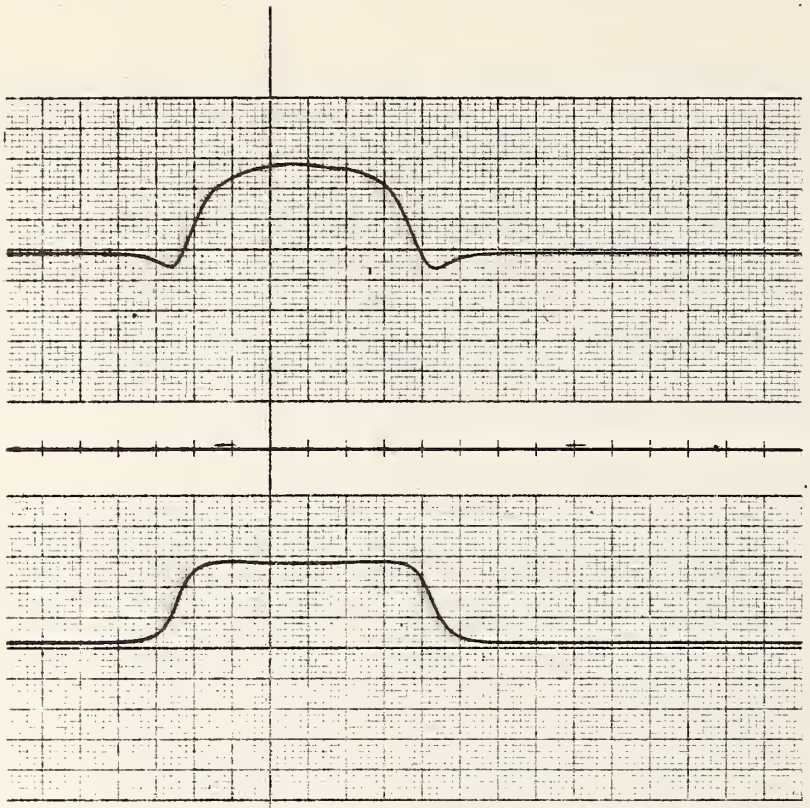

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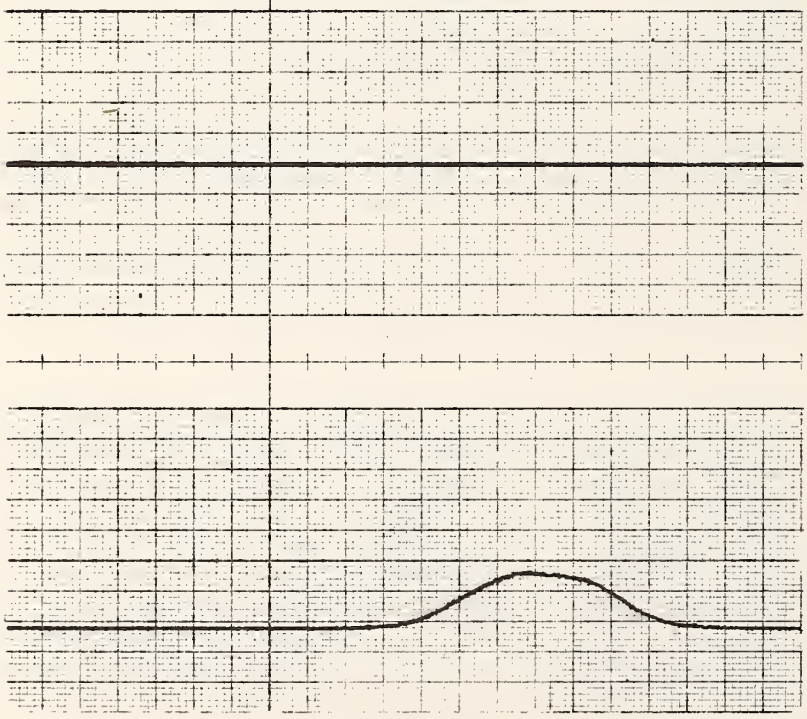

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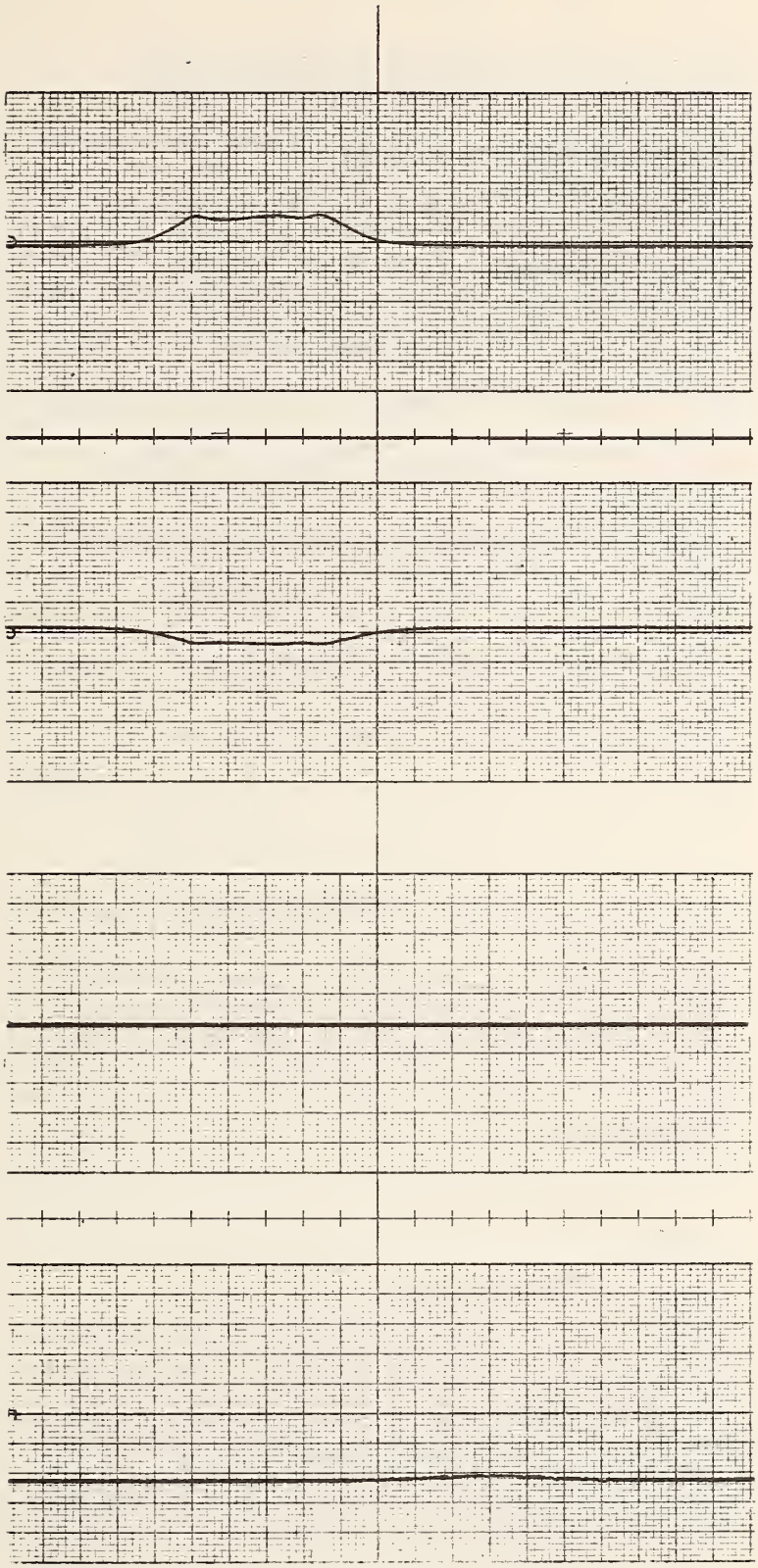

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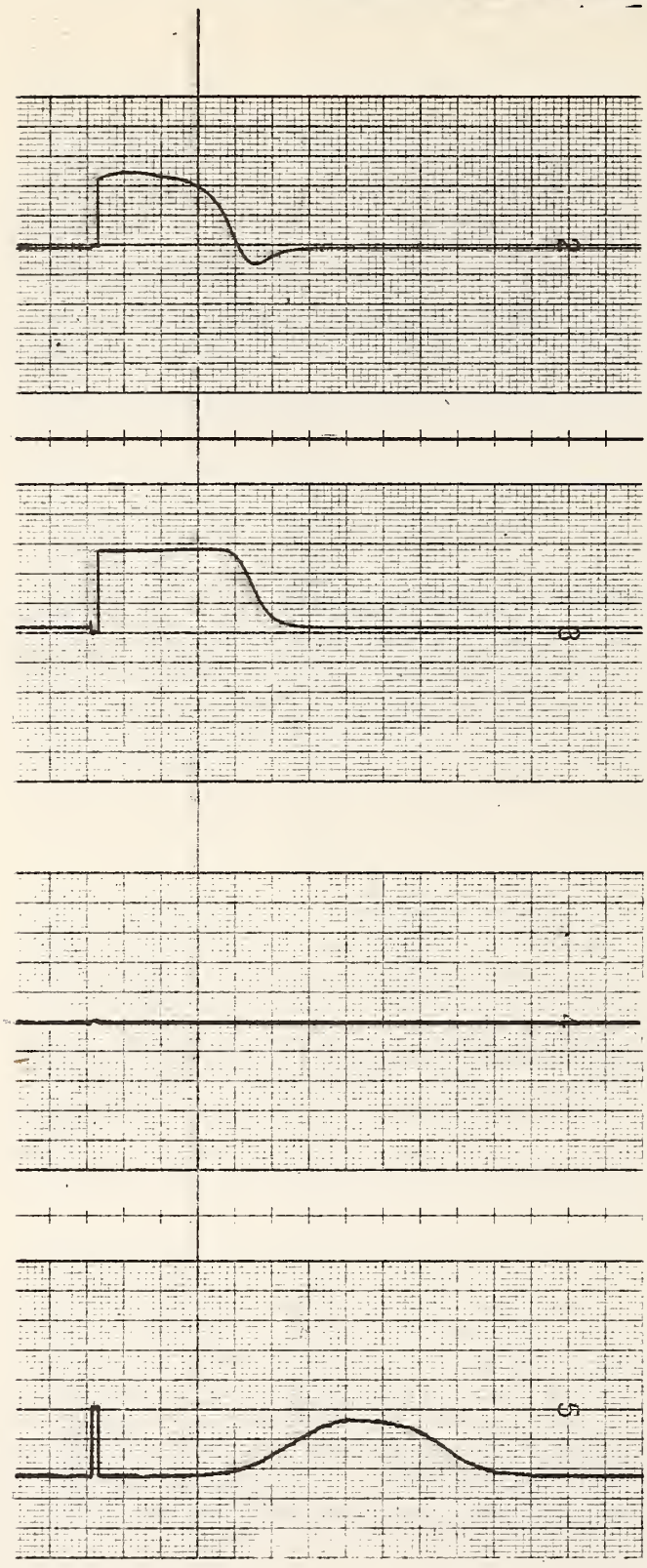
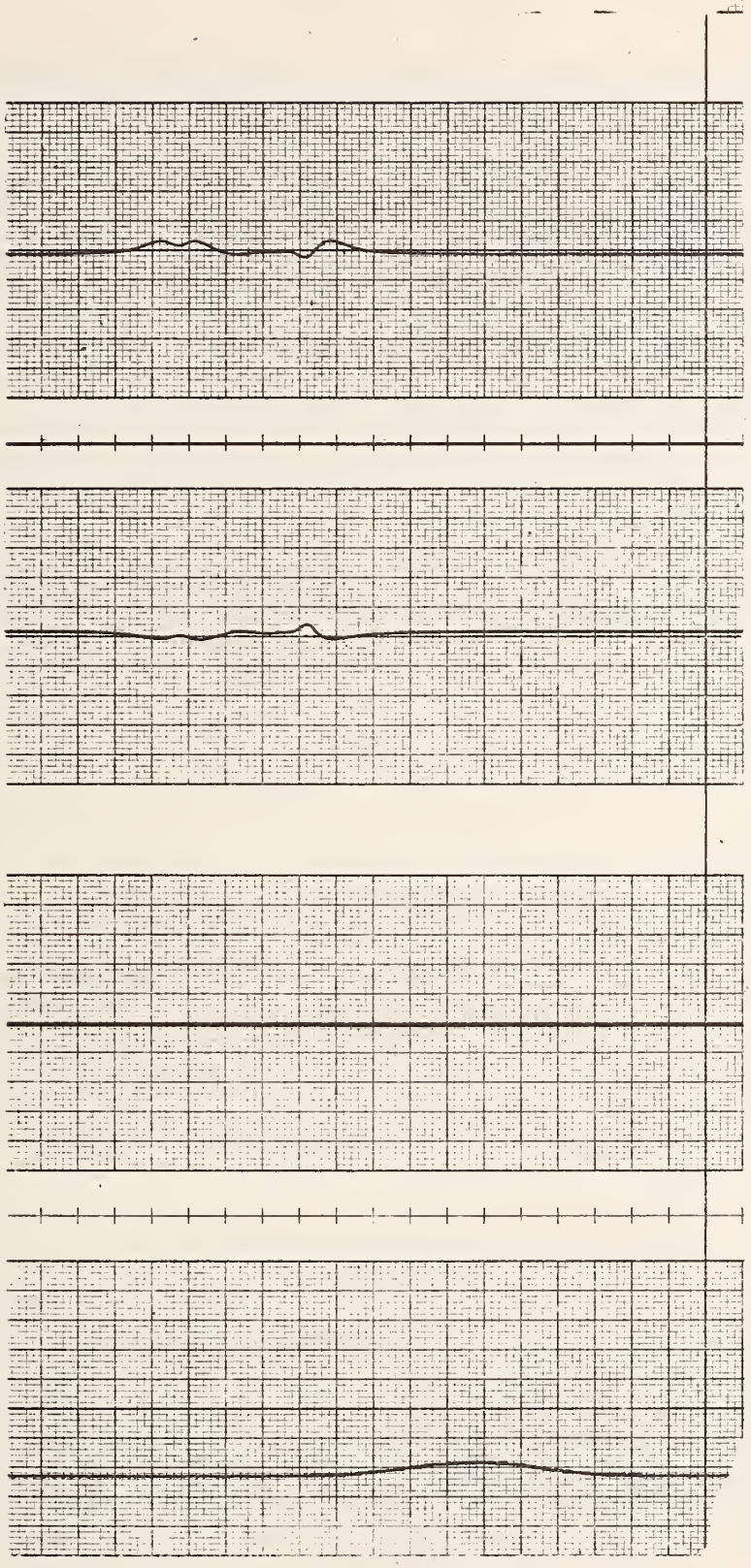


RUN 433



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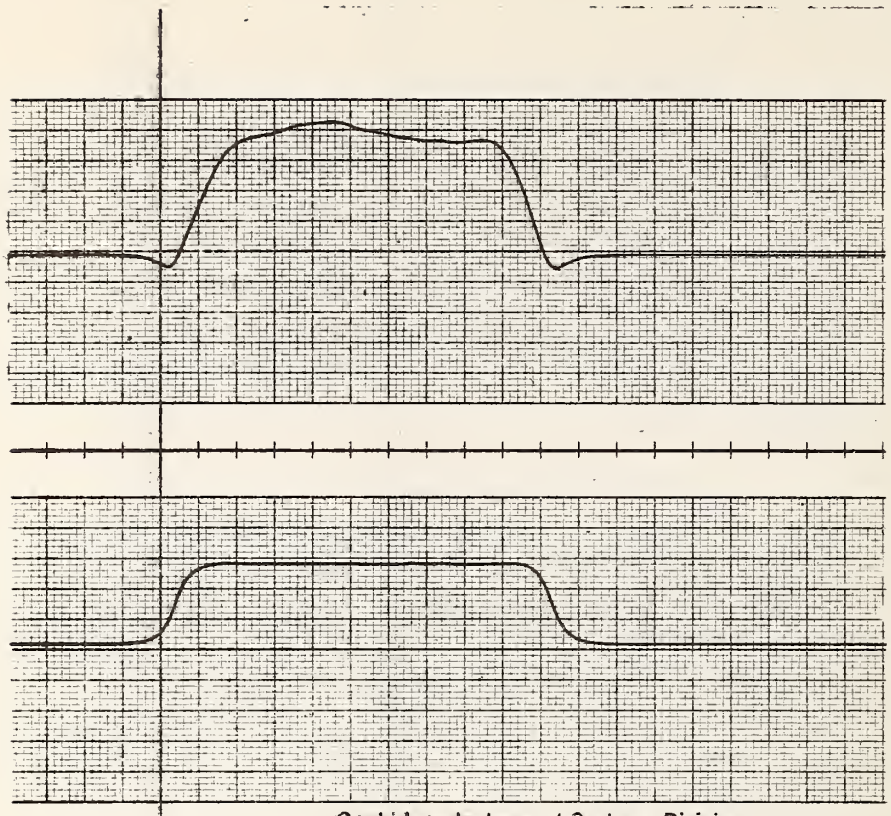

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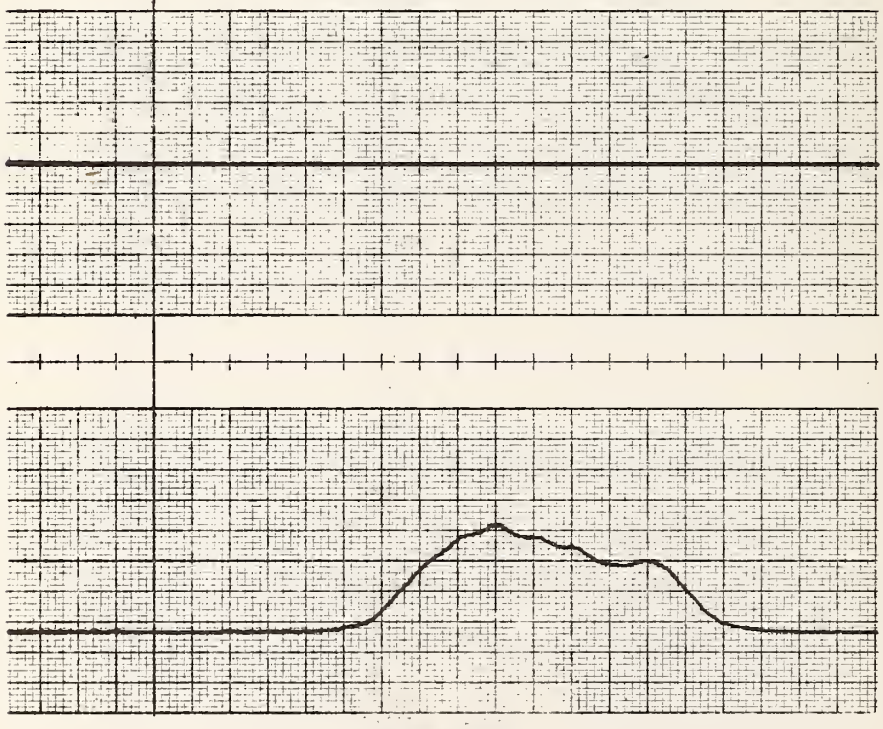

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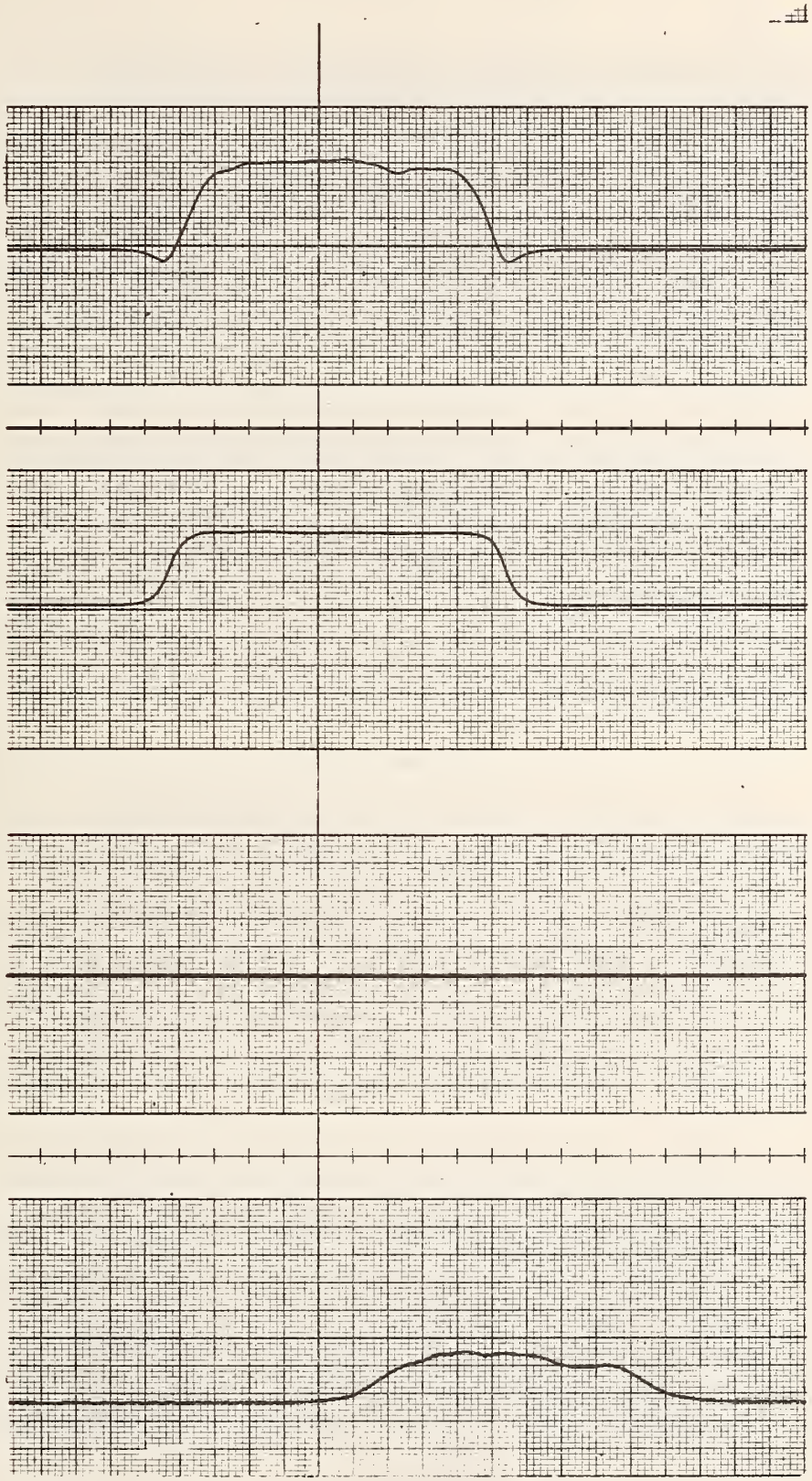

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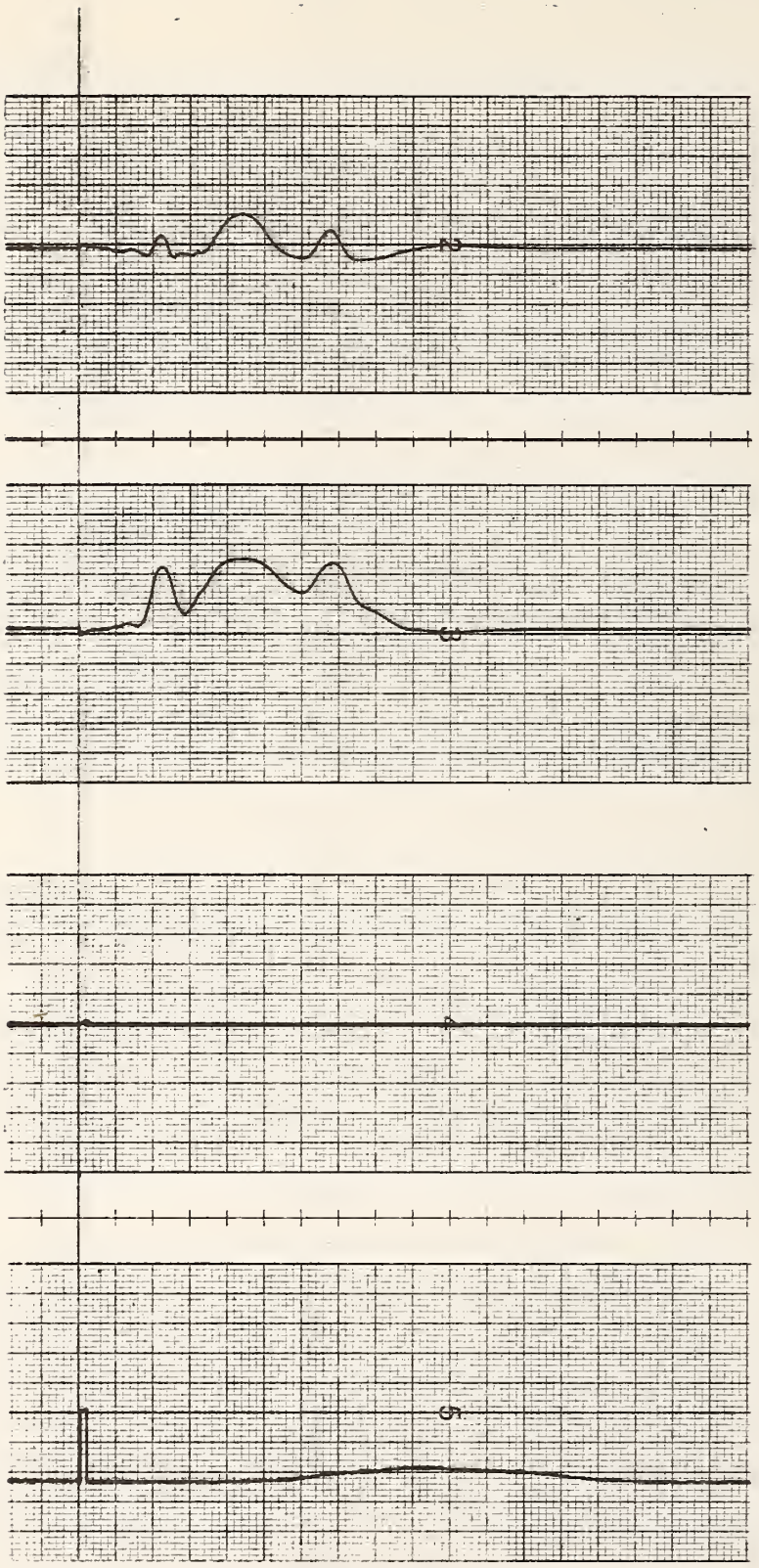
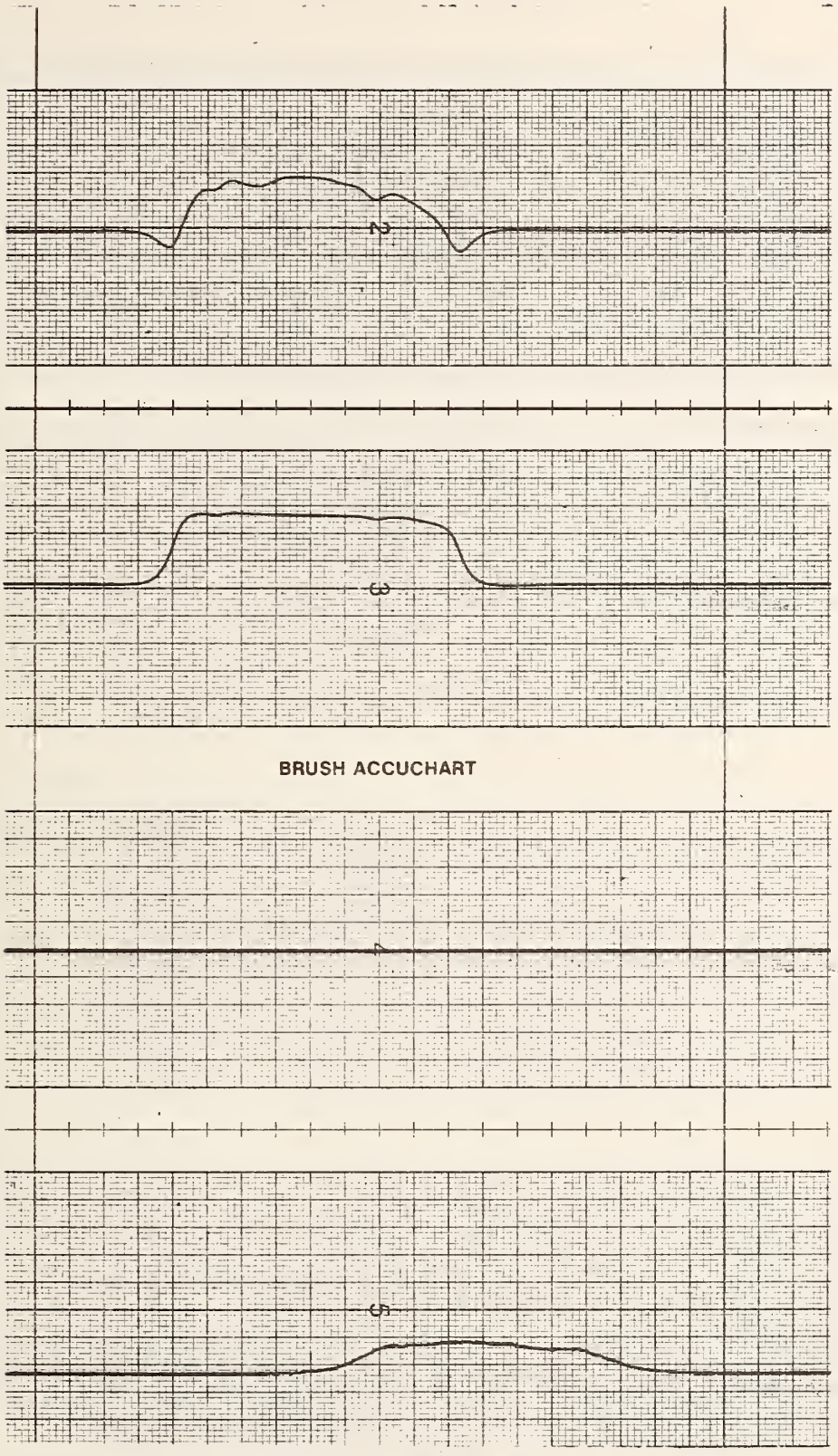


RUN 437



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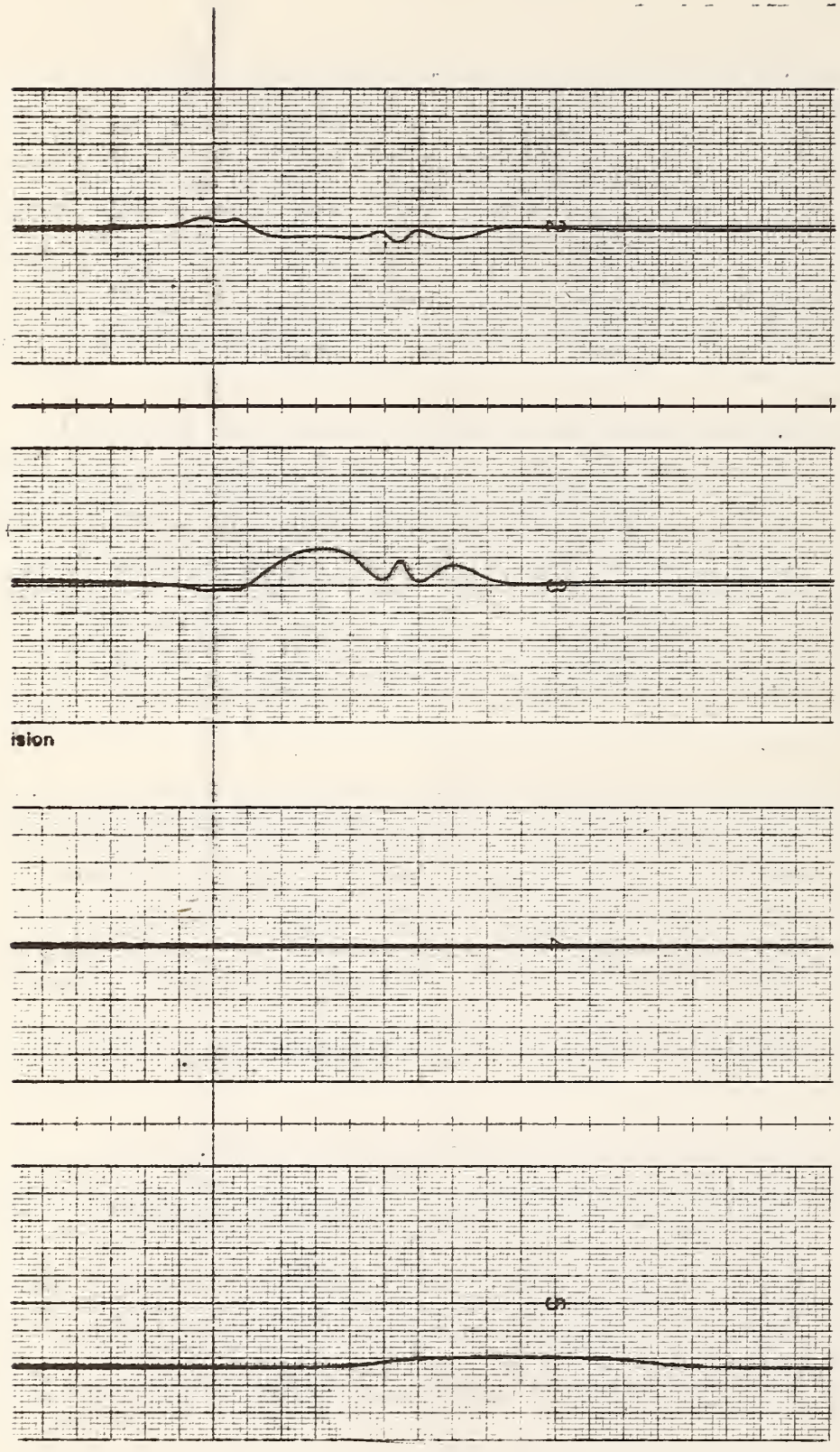

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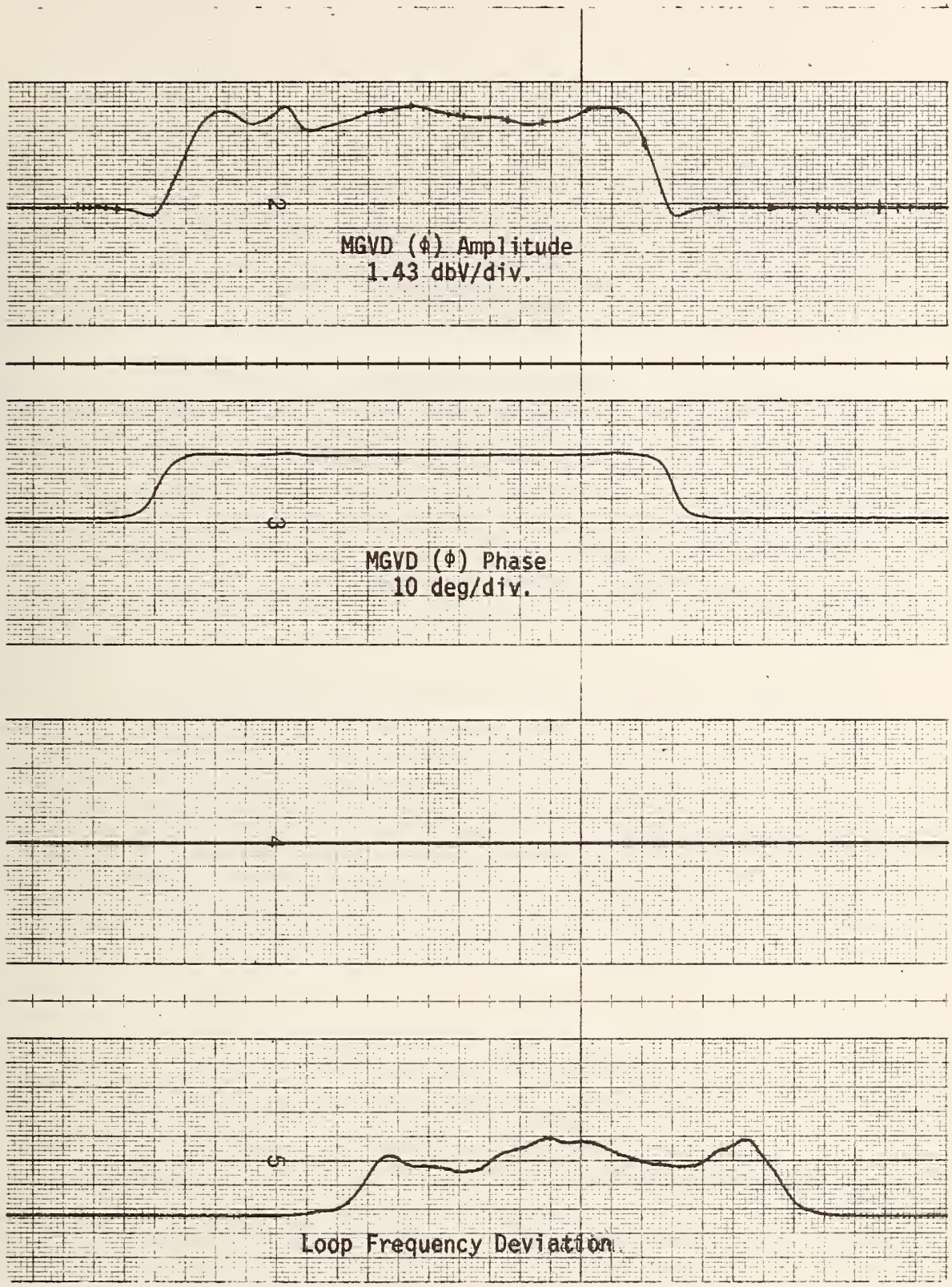
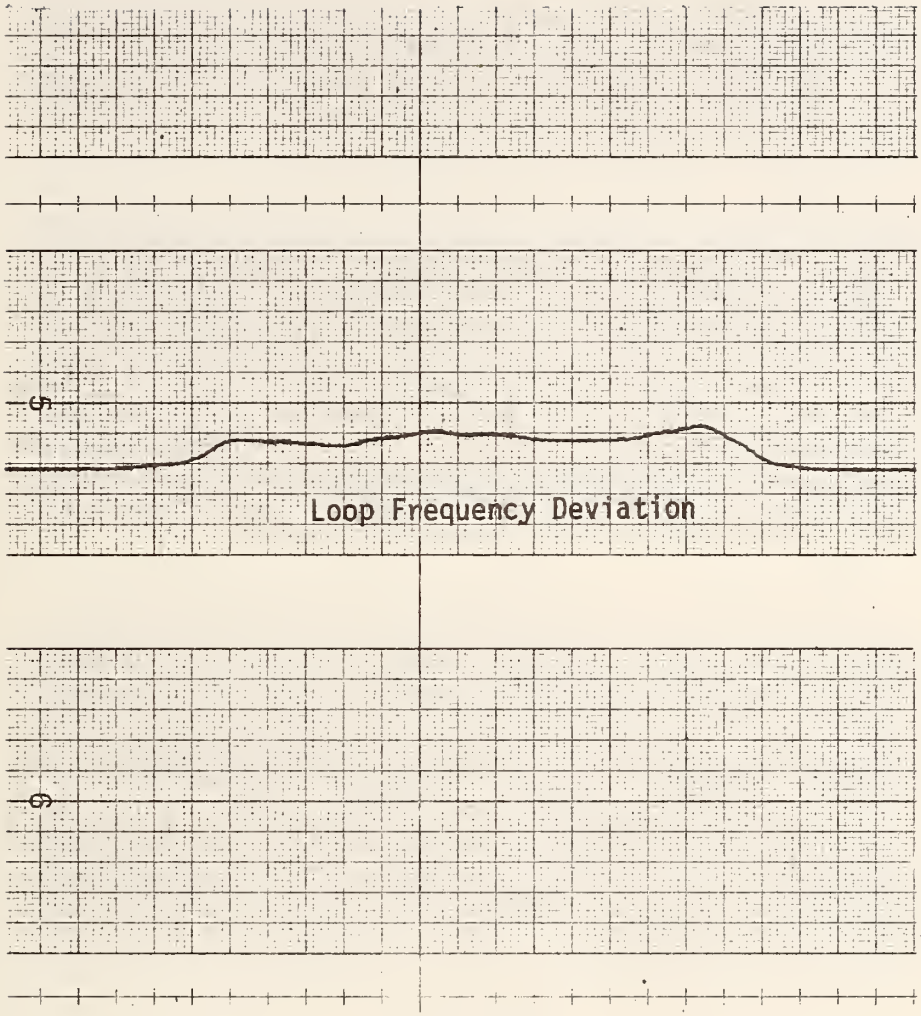


BUS 0' RUN 440

CHART SPEED 25 MM/SEC

Runs 441-449

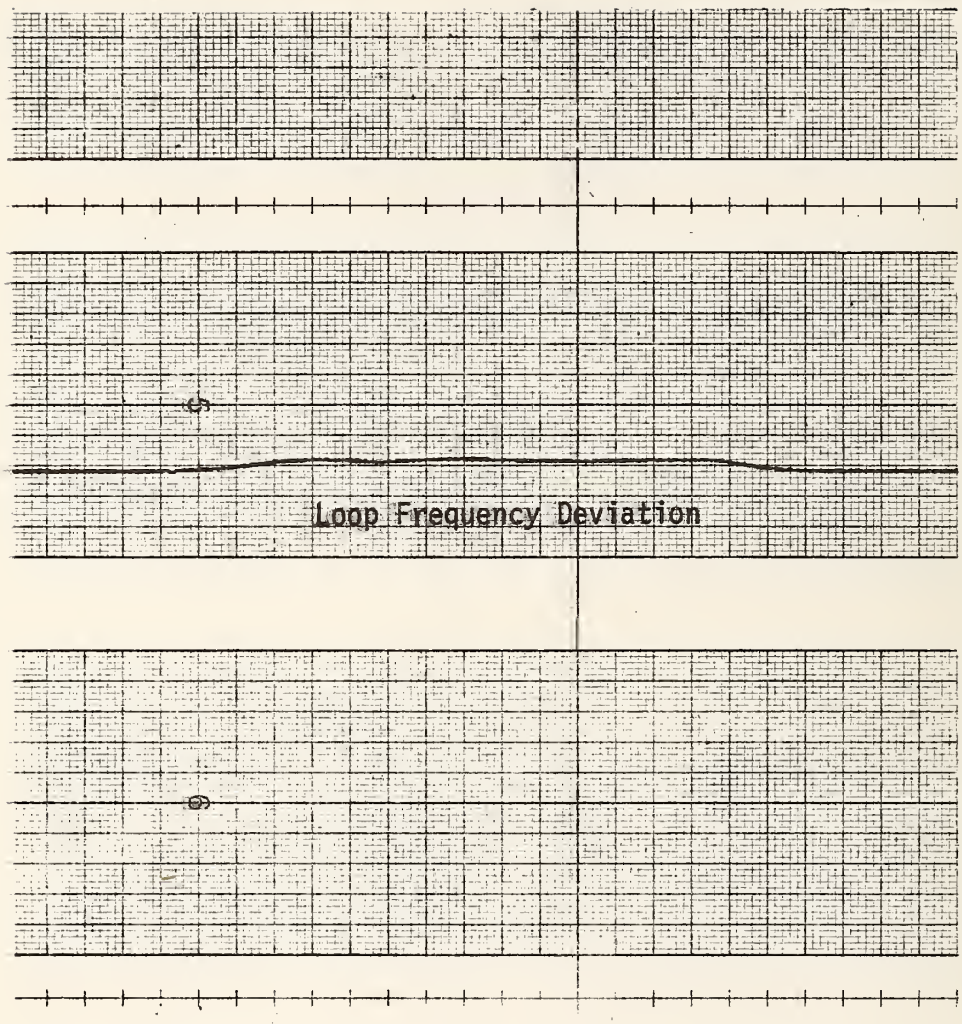
Trace 1 = ILD FM



BUS +3' RUN 441

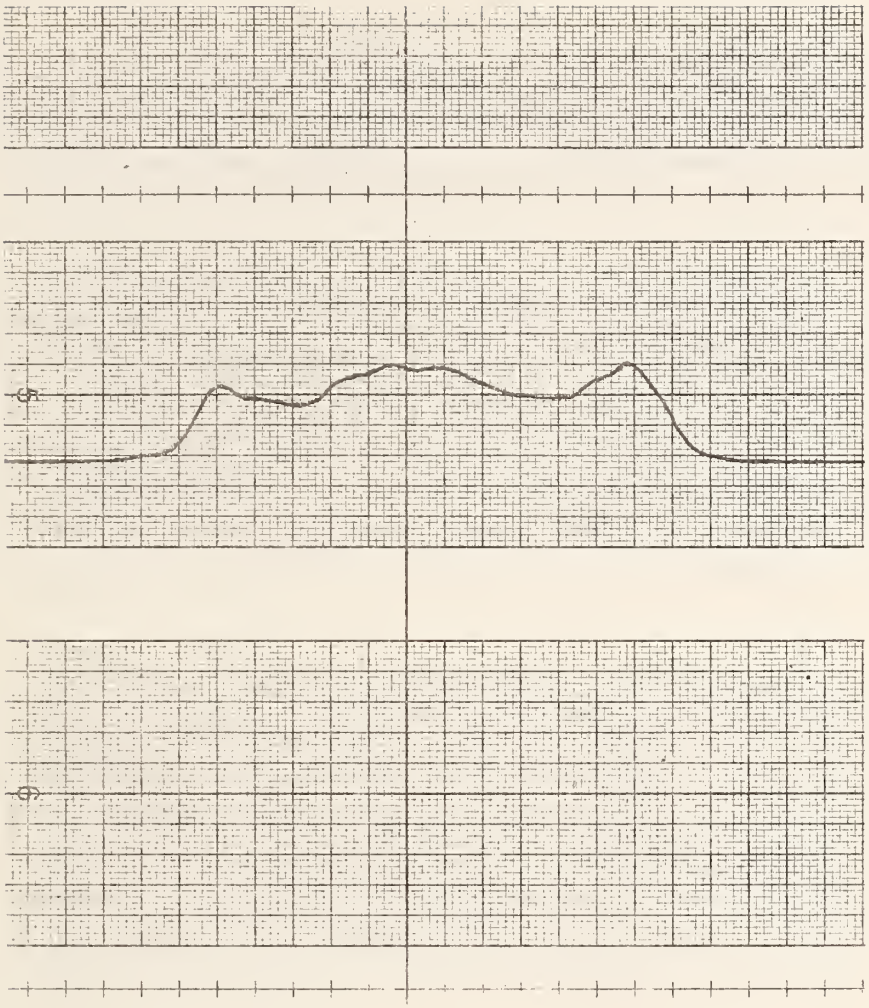
ASPHALT ROADWAY

CHART SPEED 25 MM/SEC

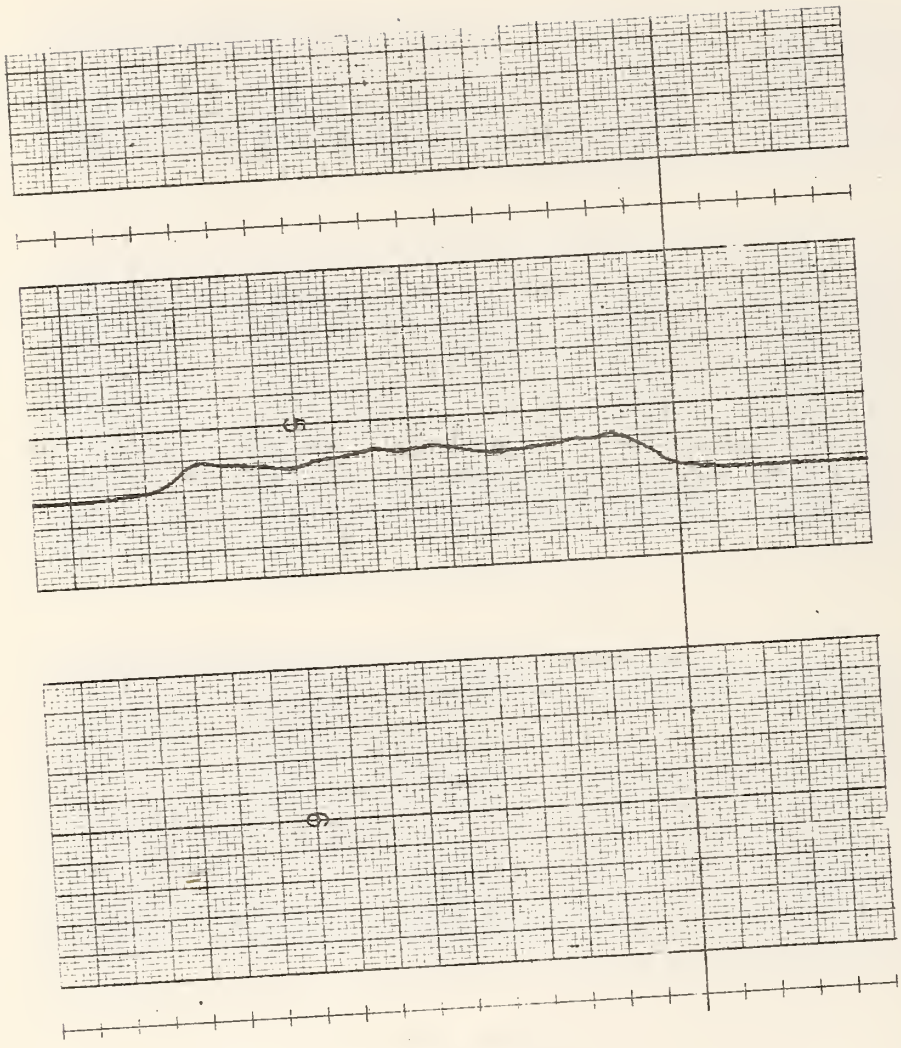


BUS +6' RUN 442

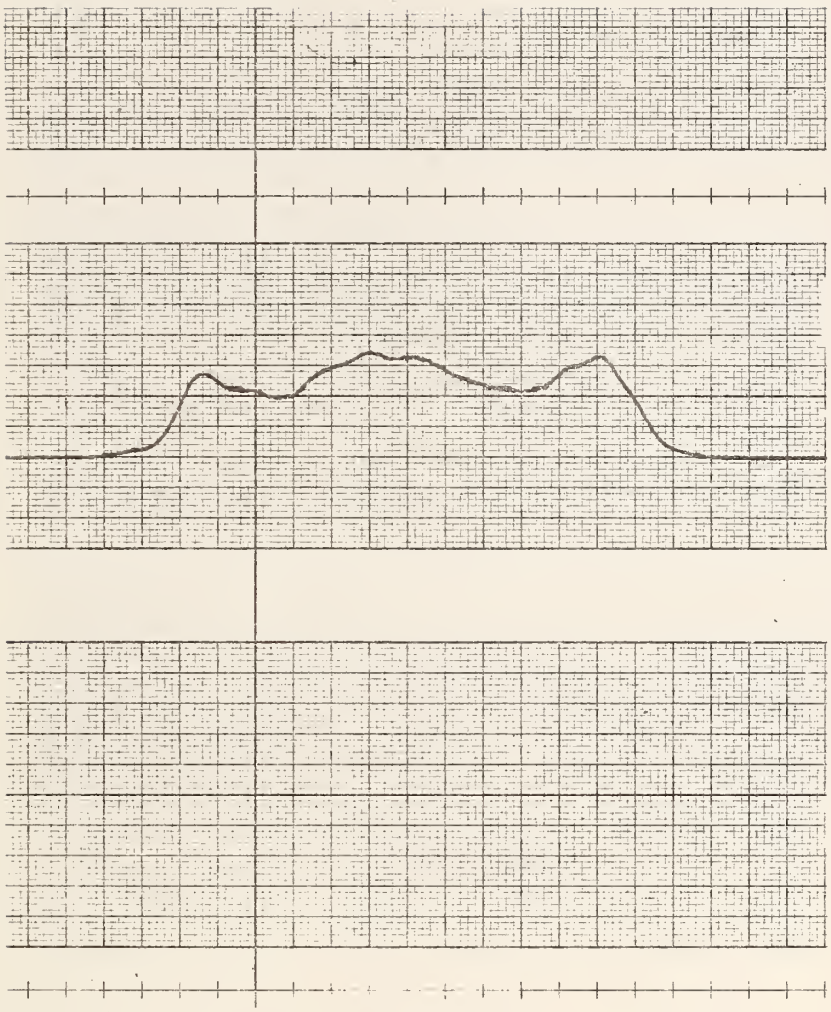
CHART SPEED 25 MM/SEC



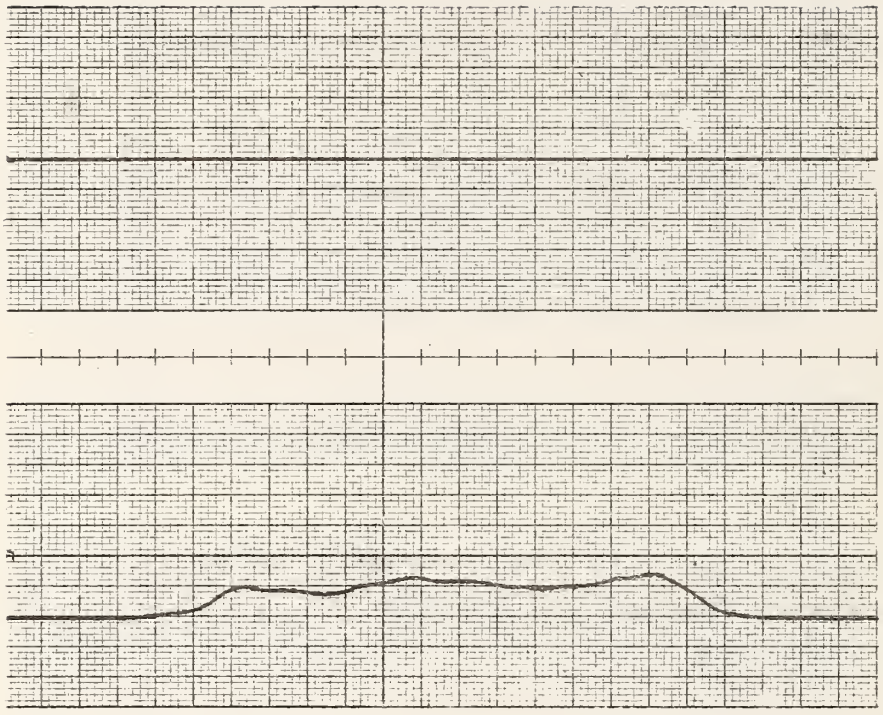
RUN 443



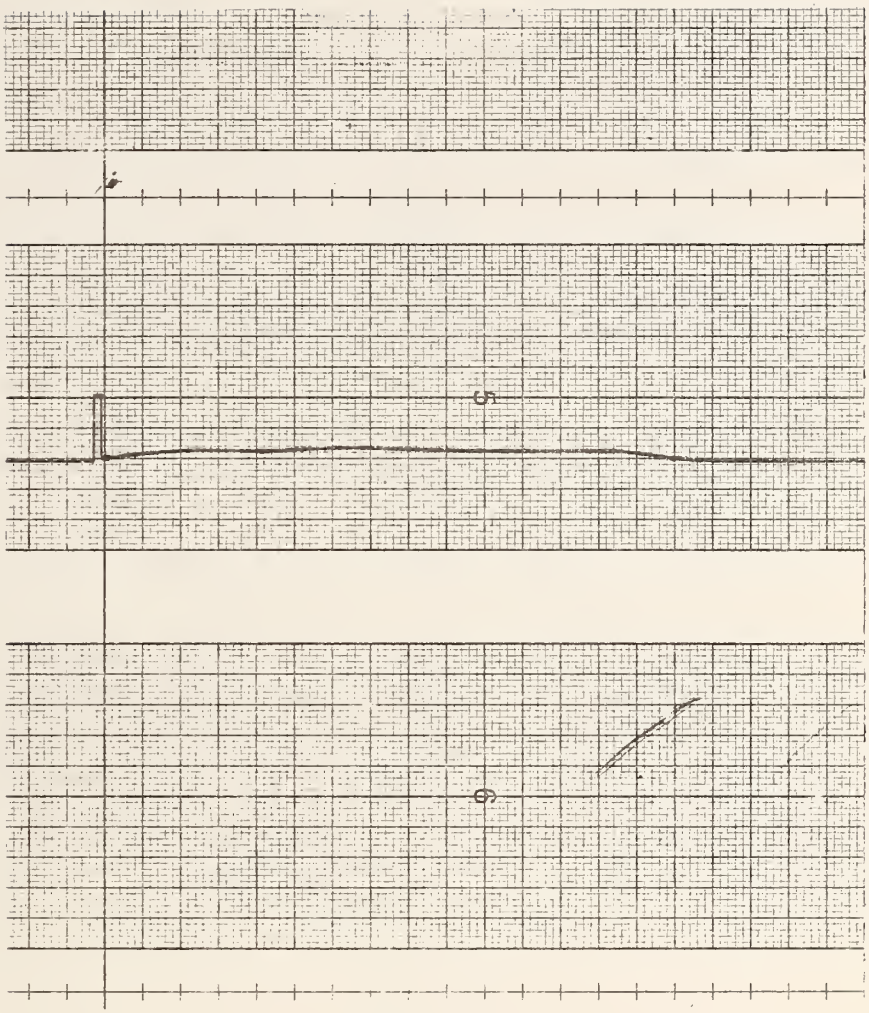
RUN 444



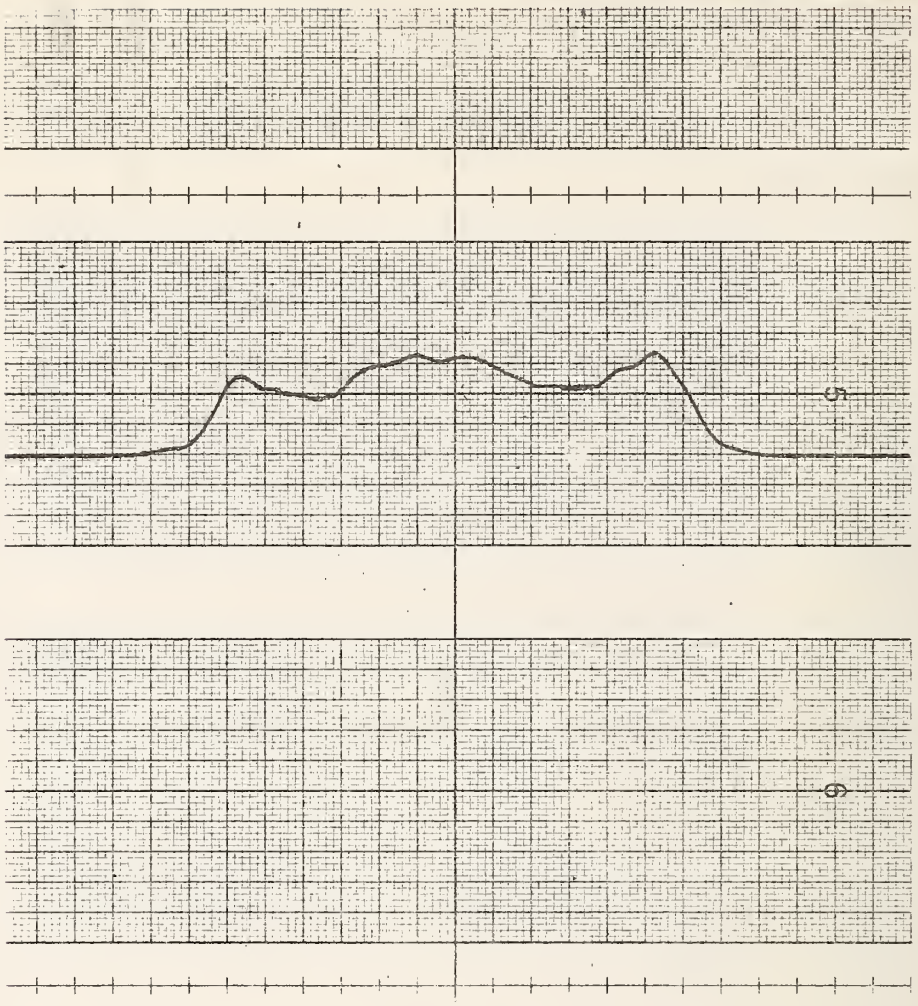
RUN 445



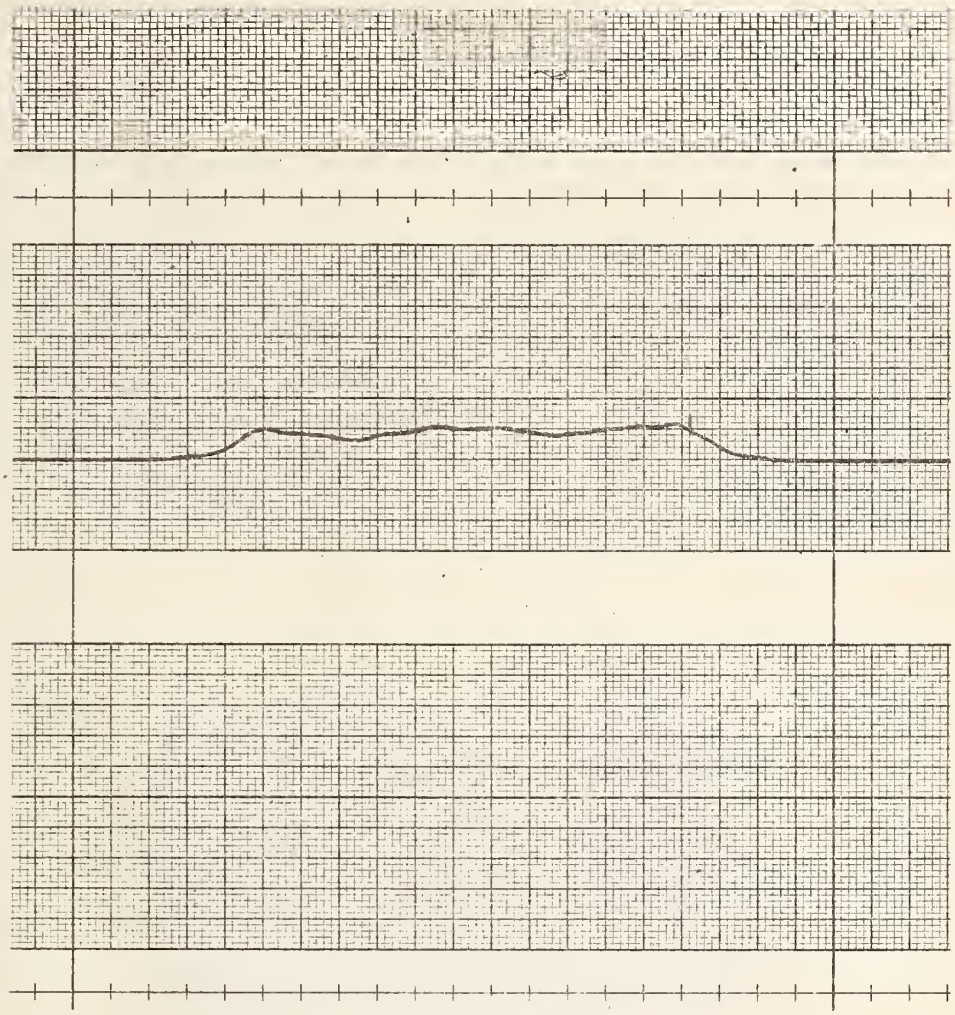
RUN 446



RUN 447



RUN 448



RUN 449

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